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Bilateral supernumerary sternocleidomastoid heads with clinical and surgical implications

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ABSTRACT

The sternocleidomastoideus muscle is one of the most complex muscles of the body. A wide mention of supernumerary and accessory musculature has been made in the literatures. In majority of cases, accessory muscles are asymptomatic and usually incidental findings at surgery or imaging. The objective of this study was to determine the prevalence of additional head of sternocleidomastoideus muscle, describe an anatomical variation of bilateral sternocleidomastoideus anatomy and review the clinical and surgical significance. A total of 16 cadavers of both sexes (15 men and 1 women) with different age group were used for the study. Head and neck region (32 sides) of the cadavers were carefully dissected as per the standard dissection procedure in the Morphology Laboratory at the University of Pamplona. The morphological variations in the number of heads (three and four) of origin of sternocleidomastoideus muscle were observed in 2 out de 16 neck (12,5%). It was found in two male subjects in right and left neck, bilaterally. The remaining 14 neck (87,5%) showed the normal origin, insertion, course of the sternocleidomastoideus and the course and branching patterns of the spinal accessory nerve and arterial patterns was normal having classic branching. The Knowledge of the presence of additional heads of Sternocleidomastoideus muscle is the interest why may cause functional deficits since its covers the important neurovascular structures of the neck; it might cause difficulties in the surgery in that region. It may also interfere in invasive techniques.

Keywords: Anatomical variations, clavicular head, lesser supraclavicular fossa, sternal head, sternocleidomastoideus muscle, supernumerary head.

INTRODUCTION

The sternocleidomastoideus muscle is one of the most complex muscles of the body. The muscle while acting alone flexes the neck laterally and turns the face to the opposite side. When the muscles of the two sides contract simultaneously, they flex head and neck, therefore is responsible for the mechanical action for the majority of the movements of the head, and it is considered to be an accessory muscle of inspiration. This muscle is an important landmark in the neck which divides it into an anterior and a posterior triangle. The sternocleidomastoideus protects the vertical neurovascular bundle of neck, branches of cervical plexus, deep cervical lymph nodes and soft tissues of neck from damage. The sternocleidomastoideus gets its motor supply from the spinal accessory nerve and the proprioceptive innervation from the cervical spinal nerves. The muscle derives its arterial supply from the occipital, posterior auricular, superior thyroid and suprascapular arteries[1].

It originates and is attached inferiorly by two heads, medial sternal head which is rounded and tendinous; and lateral clavicular head. The sternal head originates from the upper part of the anterior surface of the manubrium sterni and ascends posterolaterally. The clavicular head is variable in width and contains muscular and fibrous elements, originates from the superior surface of the medial third of the clavicle and ascends almost vertically. The two heads of origin are separated near their attachments by a triangularinterval, which corresponds to a surface depression, the lesser supraclavicular fossa. As they ascend, the clavicular head spirals behind the sternal head and blends with its deep surface below the middle of the neck, forming a thick, rounded belly. The muscle is inserted superiorly by a strong tendon to the lateral surface of the mastoid process from its apex to its superior border, and by a thin aponeurosis into the lateral half of the superiornuchal line. The clavicular fibres are directed mainly to the mastoid process; the sternal fibres are more oblique and superficial, and extend to the occiput. The direction of pull of the two heads is therefore different, and the muscle may be classed as 'cruciate' and slightly 'spiralized'[2,3].

The sternocleidomastoideus (SCM) functions as a landmark are important not only for the anatomist but also for physicians such as anaesthesiologists, general surgeons, orthopaedic surgeons, neurosurgeons, head and neck surgeons, radiologist, interventional radiologists, plastic surgeons, oral surgeons, maxillofacial surgeons, oncologists, physical therapy, physiatrists, physiotherapists, in electrophysiological studies, who intervene in the minor supraclavicular fossa located at the base of the neck. The minor supraclavicular fossa is formed by the separation of the two heads of the sternocleidomastoideus muscle. Variability of SCM anatomy may cause complications while trying to access the vital elements that are located in the minor supraclavicular fossa. For example, damage can be caused to the spinal accessory nerve, and unsuccessful cannulation of the internal jugular vein may also occur. It is of great importance for physicians to have a clear understanding of the anatomy of the SCM and its possible variations in order to avoid inadvertent complications. A wide mention of supernumerary and accessory musculature has been made in the anatomic, surgical, and radiology literatures. In majority of cases, accessory muscles are asymptomatic and usually incidental findings at surgery or imaging. However, sometimes accessory muscles may produce clinical symptoms. These symptoms may be related to a palpable swelling or compressive effect on neurovascular structures [3,4].

The purpose of this study was to determine the prevalence of additional head of sternocleidomastoideus muscle, describe an anatomical variation of bilateral sternocleidomastoideus anatomy and review the clinical and surgical significance.

EXPERIMENTAL SECTION

A total of 16 cadavers of both sexes (15 men and 1 women) with different age group were used for the study. Head and neck region (32 sides) of the cadavers were carefully dissected as per the standard dissection procedure in the Morphology Laboratory at the University of Pamplona. The described anatomic variations were dissected in the both left side and right side of two male cadavers of 75 and 47 year of age respectively. The topographic details were examined and the variations were recorded and photographed. The history of the individual and the cause of death are not known.

RESULTS AND DISCUSSION

The morphological variations in the number of heads of origin of sternocleidomastoideus muscle were observed in 2 out de 16 neck (12,5%). It was found in two male subjects in right and left neck, bilaterally. The remaining 14 neck (87,5%) showed the normal origin, insertion, course of the sternocleidomastoideus and the course and branching patterns of the spinal accessory nerve and arterial patterns was normal having classic branching.

In the male cadaver of 47 years old in the right side, it was observed that the sternocleidomastoideus muscle has three muscle bellies, arising by a tendinous head from the front of the manubrium sterni and by a broad aponeurotic head from the medial part of the upper surface of clavicle, lateral to its medial end. Additionally, an unusual prominent and broad muscular slip was also arising from the upper surface of clavicle, lateral to its medial end. The fibers of both the clavicular heads were directed vertically upwards and backwards. The fibers of the usual or medial clavicular head were fusing with the sternal fibers at a distance of 4,8 cm from the clavicle, while the distance of fusion of additional clavicular fibers with the usual clavicular fibers was 5.3 cm. The sternal, usual clavicular and additional clavicular heads were blending into a thick, rounded muscle belly which was inserted by a tendon onto the lateral surface of the mastoid process and the superior nuchal line of the occipital bone. The two clavicular heads were separated by a wider triangular interval. The lesser supraclavicular fossa was formed between the sternal and usual clavicular heads of origin. The usual as well as the additional slip were supplied by a branch from the spinal part of the accessory nerve. The additional head received its blood supply from an independent branch of suprascapular artery (Figure 1).

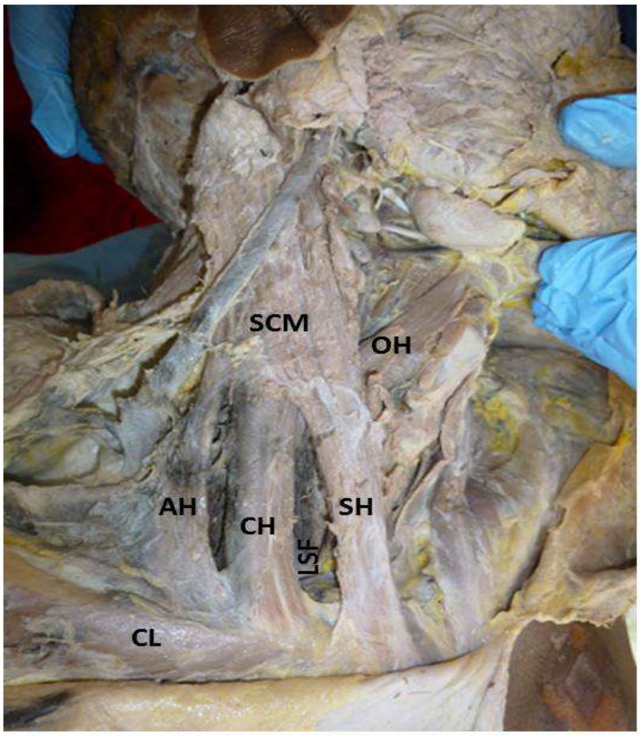

Figure 1. Superficial dissection of right side of the neck region showing three heads of sternocleidomastoideus muscle. SCM: sternocleidomastoideus muscle; SH: sternal head; CH: clavicular head, AH: additional head; OH: omohyoid muscle: LSF: lesser supra clavicular fossa; CL: clavicle

In the same male cadaver of 47 years old, on the left side, instead of a normal sternocleidomastoideus (SCM), four muscle bellies were recorded, in terms of heads one sternal and three clavicular. The medial of the four heads had anatomy corresponding to the usual sternomastoid portion of the SCM. It was extended from the sternal manubrium to the mastoid process tip. The second head extending from the sternoclavicular joint, posterior and lateral to the origin of the sternomastoid muscle. The third muscle head originated from the lateral part of the proximal third of the clavicle and terminated at the occipital bone just inferior to the insertion of the sternomastoid head. A fourth muscle head, arose from the middle third of the clavicle, coursed upwards, posteriorly, and obliquely, in a parallel course to the previously described muscle bellies and fused with the third head muscle at the level of the middle third of the anterior border of the trapezoid muscle. The non-typical arrangement of the muscle tendons on the left side of the neck created a very narrow minor supraclavicular fossa medially. Laterally, an even narrower additional minor supraclavicular fossa laterally and posterior cervical triangle was found, while the major supraclavicular fossa was shortened considerably. Figure 2.

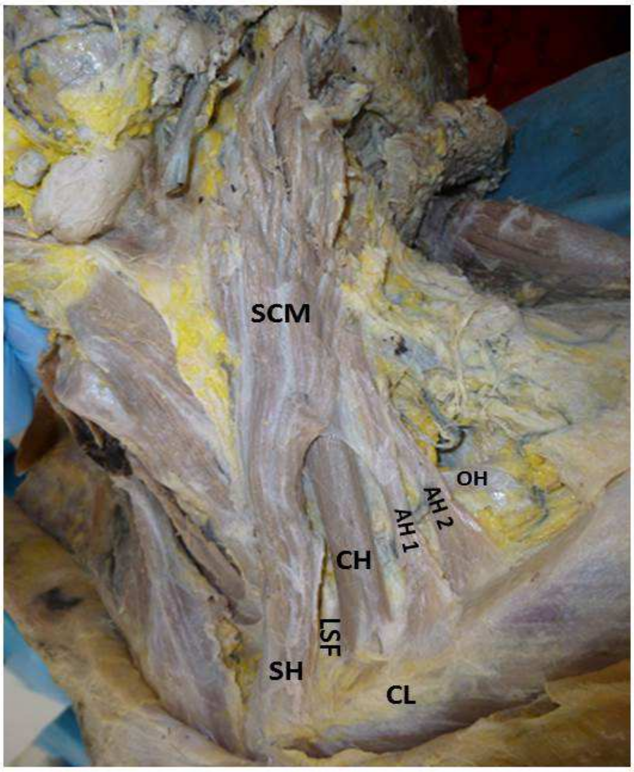

Figure 2. Superficial dissection of left side of the neck region showing four heads of sternocleidomastoideus muscle. SCM: sternocleidomastoideus muscle; SH: sternal head; CH: clavicular head, AH 1: additional head; AH 2: additional head OH: omohyoid muscle: LSF: lesser supra clavicular fossa; CL: clavicle

The presence of third head or accessory head of Sternocleidomastoideus was observed bilaterally in a male cadaver of 75 years of age:

Right Sternocleidomastoideus, it had three heads, sternal head had a rounded origin from anterior surface of the manubrium sterni, got inserted to the mastoid process and superior nuchal line of occipital bone. Clavicular head originated from superior surface of medial one third of clavicle. Before insertion it merged with deeper surface of the sternal head from clavicle and got attached to the mastoid and occiput deep to the sternal head. Additional head which had its origin from superior surface of clavicle, 3,5cms from the sternal end of clavicle about 0.7 cm wide, it merged with sternal head above the clavicular head at a distance of 3,8cms from the clavicle, then it got attached to the superior nuchal line for insertion corresponding to the fibres of sternal head. At the fusion of the clavicular heads with the sternal head it was 2cms wide. Figure 3.

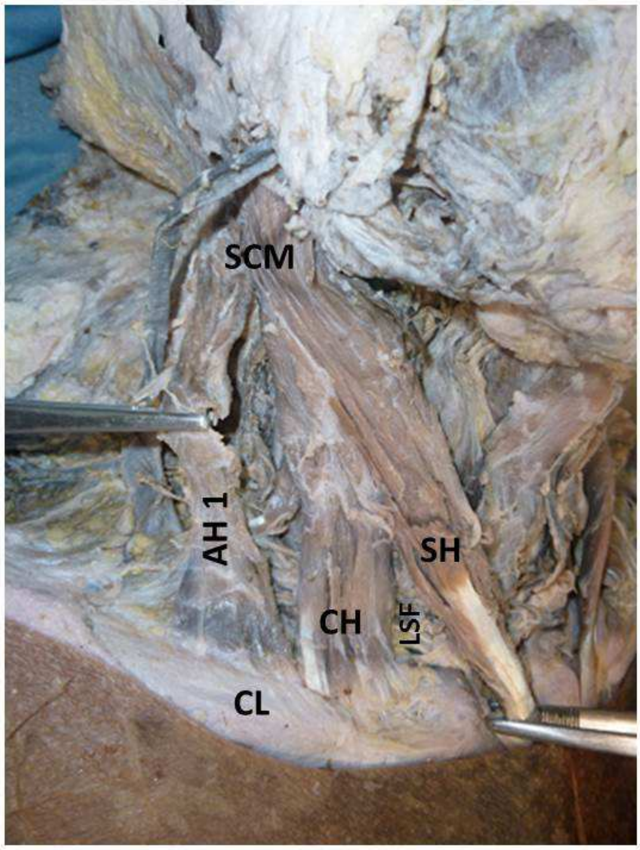

Figure 3.Superficial dissection of right side of the neck region showing four heads of sternocleidomastoideus muscle. SCM: sternocleidomastoideus muscle; SH: sternal head; CH: clavicular head, AH 1: additional head; LSF: lesser supra clavicular fossa; CL: clavicle

Left Sternocleidomastoideus: It had three heads. Sternal head origin was rounded from the anterior surface of the manubrium sterni, inserted to the mastoid process and superior nuchal line of occipital bone. Clavicular head originated from superior surface of medial one third of clavicle. Before insertion it merged with deeper surface of the sternal head and got attached to the mastoid and occiput deep to the sternal head. Additional head originated from superior surface of clavicle, 4cms from the sternal end of clavicle. Before insertion it merged with sternal head above the clavicular head at about 6,5cms from the clavicle, then it got attached to the superior nuchal line for insertion corresponding to the fibres of sternal head. Figure 4.

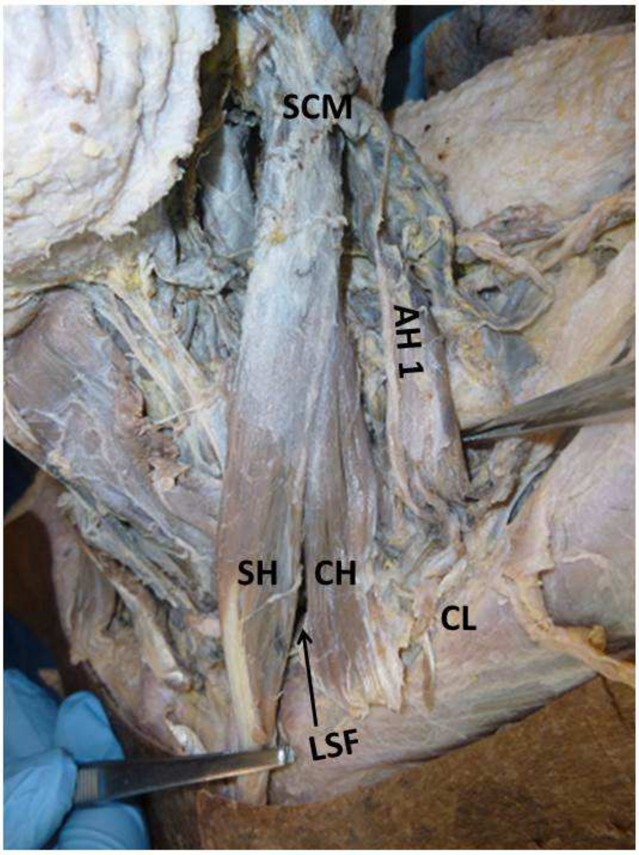

Figure 4.Superficial dissection of left side of the neck region showing four heads of sternocleidomastoideus muscle; SCM: sternocleidomastoideus muscle; SH: sternal head; CH: clavicular head, AH 1: additional head; LSF: lesser supra clavicular fossa; CL: clavicle

All the normal and additional head of sternocleidomastoideus muscle found were covered by the investing layer of the cervical fascia, and were innervated mainly by the spinal accessory nerve.

The SCM is a unique muscle, in terms of variations at its origin (4-7) Also, it has a variable innervations arrangement, the " classical anastomotic pattern " being observed in 50 % of the cases.Variations in origin of both heads of sternocleidomastoideus muscle have been reported but variations in clavicular head are more common than sternal head. Usually the clavicular origin is narrower than the sternal head. When the clavicular origin is broad; it is subdivided into several slips separated by narrow intervals.

Morphological variations of the SCM.

In many animals, the cleidomastoid belly is distinctly separate from the sternomastoid belly. (Fig. 5d) This condition when present in humans is considered to be a variation from normal [5,8]. The two separate sternomastoid and cleidomastoid bellies further subdivide the anterior triangle into a supernumerary triangle. This extra triangle can also be considered as an extended lesser supraclavicular fossa which normally separates the sternal and clavicular heads of origin of SCM. The occurrence of such a variation can be explained by fusion failure or abnormal mesodermal splitting during development. In this regard we may refer to Sinohara's law of fusion which states that a muscle supplied by two different nerves is formed by fusion of two separate muscle masses [5,9].

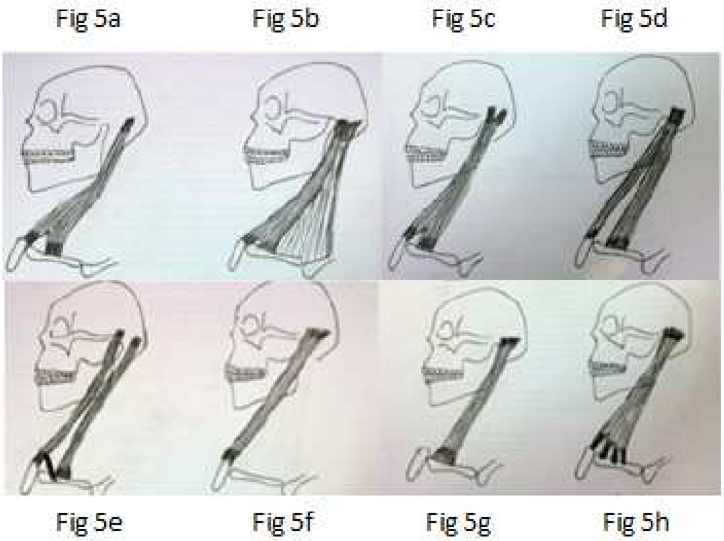

Figure 5. Morphologic variations of the Sternocleidomastoid (From reference 5) Muscle
Fig.5a: sternocleidooccipital belly with absent mastoid insertion
Fig.5b: fusion of sternocleidomastoideus with trapezius
Fig.5c: lateral and medial slips of sternocleidomastoideus insertion on mastoid
Fig.5d: separate bellies of sternocleidomastoideus andcleidomastoid with extended lesser supraclaavicular fossa
fig 5e: cleido occipital belly separate from sternocleidomastoideus belly
fig 5f: sternomastoid with absent clavicular head
fig 5g:cleidomastoid with absent sternal head
fig 5h: supernumerary clavicular heads

Some studies have indicated a supernumerary cleidooccipital muscle more or less separate from the sternocleidomastoideus muscle [10] (Fig 5e). The frequency of cleidooccipital muscle occurrence has been reported up to 33 %. [5,11,12].

Occasionally, the SCM fuses with the trapezius, leaving no posterior triangle. (Fig2b) Such a phenomenon describes Sinohara's law of separation which states that two muscles (SCM and trapezius) having common nerve supply (accessory nerve) are derived from a common muscle mass [5,9].

There are reports of a broad clavicular head splitting into multiple small muscular slips. [5,10,13,14] (Fig 5h). The number of these extra clavicular slips may vary and such occurrence may be unilateral or bilateral. They cause formation of supernumerary lesser supraclavicular fosse. Developmentally, these additional muscle slips indicate abnormal mesodermal splitting in posterior sixth branchial arch. They may not cause any functional advantage or disadvantage in neck movement but might be physically interfering during invasive procedures. However, they can be effectively utilized for muscle flap harvests [5].

There are also cases presenting with extra sternal and clavicular heads of origin in SCM. [5,7,10,15] These additional heads, may be unilateral or bilateral and cause significant stenosis of the lesser supraclavicular fossa, imposing complications for anesthesiologists during the anterior central venous catheterization approach.

Embryology

During the development, Sternocleidomastoideus and trapezius muscles share a common premuscle mass from the last two occipital and upper cervical myotomes. This muscle mass splits and separates at 9 mm stage of development [16]. This myotome segregates into the ventral Sternocleidomastoideus and dorsal trapezius. The trapezius and Sternocleidomastoideus arises from a common pre-muscle mass in the occipital region just caudal to the sixth branchial arch. Therefore, occasionally the margins of these two muscles make contact with each other. Moreover, HOX D4 and somitic mesoderm contributes to the development of these muscles where they are connected to skeletal elements only by posterior otic neural-crest derived connective tissue. Since HOX D4 and somites contribute muscle cells to branchial neck muscles, these myoblasts seem to associate with neural-crest derived muscular connective tissue [17].

CLINICAL AND SURGICAL IMPLICATIONS.

Anesthesiology and intensive care medicine and critic.

Anaesthetists and intensivists for central venous catheterization prefer internal jugular vein cannulation, as this approach has a lower incidence of pneumothorax. Any variation in origin of Sternocleidomastoideus muscle can lead to narrowing of lesser supraclavicular fossa, which can complicate internal jugular vein,sublavian, external jugular vein cannulation. [19].

The anatomical variations in number of bellies of the SCM muscle could lead to potential problems in interscalene brachial plexus block. Ultrasound guidance may reveal anatomical variations of importance for performing brachial plexus blocks and should be preferred over classic blind methods such as nerve stimulation. If the needle is misplaced this could result in poor preoperative anesthesia or postoperative analgesia, risk of nerve injury, hemorrhage, local anesthetic toxicity from increased dosage administration, additional head of SCM could potentially mislead the ultrasonographer to misinterpret the muscle as the middle scalene muscle thus leading to insufficient brachial plexus block [20].

Parotid surgery

Sternocleidomastoideus can be used in several ways by the surgeons who harvest these muscle flaps for reconstructions such as during parotid surgery where the Sternocleidomastoideus muscle flap may cover the surgical defects and possibly preventing Frey’s syndrome. It can be used as myocutaneous flap for facial defects, carotid artery protection and repair of oral cavity defects and reconstructions of the oral floor. [21]

Plastic surgery and head and neck surgeons

A myocutaneous flap including an additional head of sternocleidomastoideus is of great use to the plastic surgeon because of its adequate vascularity and presence of sufficient tissue to be transferred to the recipient site. The segments of the SCM may be utilized as a muscle or myocutaneous flap for the reconstruction of regional soft tissue defects after traumatic and oncologic head & neck procedures, thus rehabilitation of oral cavity defects, reanimation of the face, aiding in shoulder elevation, added protection to the carotid and innominate arteries, its use along with a part of clavicle to reconstruct mandible, reconstruct mandibular defects. The preserved segments of the SCM prevent the possibility of significant drooping and limitation in shoulder-joint movements [20].

The presence of aberrant or supernumerary muscles in the lateral neck region can limit the access and make difficult the dissection of level IV and V cervical lymph nodes and neurovascular elements during a variety of surgical procedures. [20]

Patients with cancer in neck sometimes develop radiation induced cervical muscle spasm which can be relieved by botulinum toxin which is commonly injected in sternocleidomastoideus muscle. Individuals with additional heads of sternocleidomastoideus may need a larger dose of medication [22,23].

Electromyographic activity

Electromyography (EMG) and the potentials recorded from sternocleidomastoideus muscle in response to electrical stimulation of the spinal accessory nerve at neck for the better determination of site of lesions. This method can be useful in the evaluation of patients with amyotrophic lateral sclerosis. To evaluate the effect of levodopa, in Parkinson’s disease elctromyographic activity of sternocleidomastoideus muscle studied [24,25].

Radiology

The SCM serves as an important soft tissue landmark in the interpretation of magnetic resonance imaging scans. The posterior border of sternocleidomastoideus is an important landmark for radiological parameter so additional heads should be kept in mind while judging the various levels of Computed Tomography(CT) and Magnetic Resonance Imaging(MRI). Moreover, the presence of anatomical variations in origin, insertion and number of bellies could alter the dosage of botulinum toxin injections administered to patients with irradiation-induced muscle spasm. Patients with supernumerary muscles would require higher doses of such an injection; additionally, may aid the surgeons intervening in the anterior and lateral neck region in order to avoid unwarranted manipulations and possible damage to cardinal structures. Aberrant or supernumerary muscles of the neck could be observed as soft-tissue shadows in modern CT and MR imaging. Three-dimensional reconstruction of the soft tissues and muscles in the suspicious area could assist in avoidance of any differential diagnosis pitfalls [19,20,25,26].

Physical examination
The accessory SCM muscle could mimic pathological masses of the lateral neck region and can be confused with soft tissue masses such as lymphadenopathies; on clinical and imaging studies including metastatic disease, or benign tumors such as cyst, glomus tumor, neurofibroma, thrombosed vein, hematoma, familiar sternocleidomastoideus tumor of infancy, and hypertrophy of the SCM [20]

Orthopedics
Diagnosis of mid shaft clavicle fractures by history, examination, and radiography is relatively straightforward .The medial segment is pulled superiorly by the sternocleidomastoideus. The weight of the arm pulls the lateral segment inferiorly through the coracoclavicular ligaments, but is opposed by the trapezius. In addition, the pectoralis major and latissimusdorsi pull the lateral segment in feromedially with resultant shortening. Figure 6.

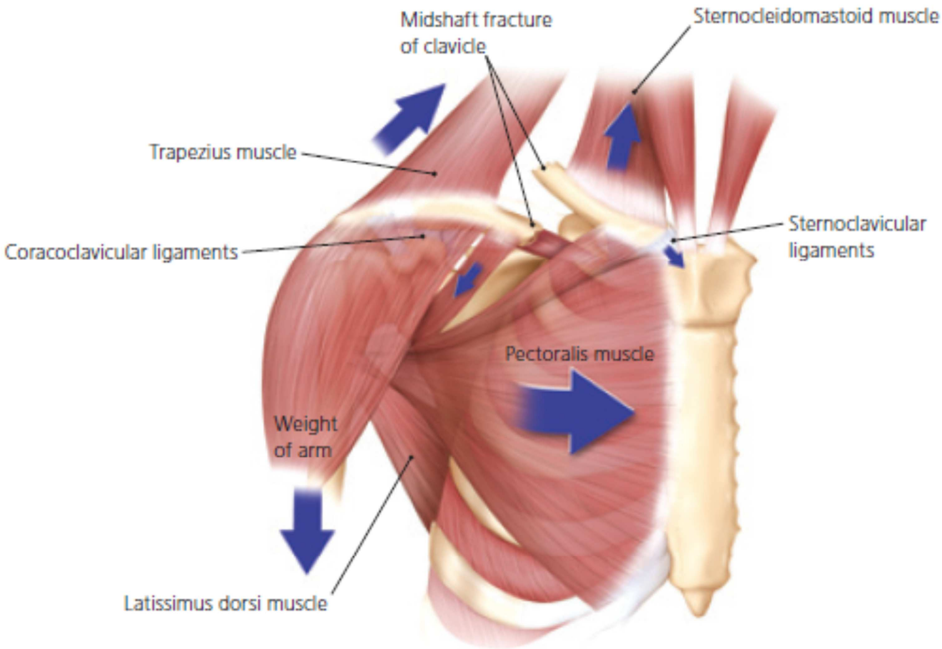

Figure 6.Deforming forces on displaced midshaft clavicle fracture.(from reference 27)

The original classification by Neer in the 1960s described two types of distal clavicle fractures: type I, in which the coracoclavicular ligaments remain intact; and type II, in which the coracoclavicular ligaments are torn from the medial fragment and only the trapezoid ligament remains attached to the lateral fragment [28]. The classification was later revised to include type III fractures, which involve extension into the acromioclavicular joint; type IV fractures, which are seen in children and involve disruption of the periosteal sleeve rather than an actual bone fracture; and type V, which involve an avulsion of the ligaments with a small inferior cortical fragment [29]. Types I and III fractures are inherently stable and do not displace; therefore, these types of fractures can be treated nonoperatively with a sling for comfort and early range of motion exercises as pain allows [30]. Bony union occurs by six weeks, but return to contact sports should be delayed for two to four months until the bony union is solid. Much of the controversy in the literature in treating distal clavicle fractures centers around how best to treat type II fractures, which have a tendency to displace. The lateral fracture fragment is held in place by the coracoclavicular ligaments, but pulled downward and medially by the weight of the arm and by the pectoralis major and latissimusdorsi muscles, while the medial fragment is pulled superiorly by the trapezius and sternocleidomastoideus muscles. Because of this displacement, there tends to be a high rate of nonunion [31,32]. Despite this, outcome studies have demonstrated similar results in terms of function, strength, and pain in fractures united operatively, those united nonoperatively, and those that go on to nonunion. [33,34]Therefore, even displaced fractures can be treated nonoperatively in the same way as types I and III fractures. However, the decision to treat a displaced type II fracture operatively in the acute setting may be made. [27].In concordance with the above mentioned, the presence of supernumerary heads of SCM may affect the usual mechanism of a clavicle fracture and have a direct effect on bone fragments, diagnoses and treatment; malunion may impair these functions. In addition, callus formation or displacement can lead to thoracic outlet compression.

According to comparative anatomy, the sterno-cleidomastoid muscle is composed of four muscles, which are the sternomastoid, the sternooc-cipital, the cleidomastoid, and the cleidocranial occipital. It is also called the “quadrigeminum muscle of the neck”. In humans the four beams forming the quadrigeminum are more or less welded instead of staying in a state of complete independence, as in some animal species. However, other comparative anatomical studies have concluded that the sternocleidomastoideus muscle is composed of five parts arranged in two layers**:** a superficial layer consisting of a superficial sternomastoid, sterno-occipital, and a clei-dooccipital part, and a deep layer consisting of a deep sternomastoid and a cleidomastoid part. To these five parts a sixth has been seen and de-scribed as *sternomastoideusprofundus*. The names adequately indicate the attachments of the various parts. The amount of fusion of the two layers of this muscle varies considerably. They are frequently separated into cleidomastoid and sternomastoid parts; this has been regarded as normal by some authors [22].

In concordance with Raikoset at [20]. In the present study the multiple bilateral muscular variations presented in this study are rare and their combination in the same subject comprises a unique case with significant surgical, radiological, and anesthesiologic interest. In addition, the supernumerary muscles, if their presence is identified, could serve as an excellent candidate for myocutaneous flap for the reconstruction of deficits after parotidectomy, oral cavity tumor resection, and esophagoplasty.

The SCM provides the mechanical basis in a wide variety of head movements and is considered an accessory muscle in respiration. The presence of supernumerary bellies of the SCMmay possibly influence muscular biomechanics. The additional clavicular bellies may provide a functional advantage, as it serves to augment the usually present clavicular head.

CONCLUSION

The Knowledge of the presence of additional heads of SCM muscle is the interest in clinical and surgical procedures.In most cases, these muscles go unnoticed as they do not produce any symptoms in the individual.Sternocleidomastoideus muscle abnormalities have defined embryological basis and several clinical presentations which may cause functional deficits since its covers the important neurovascular structures of the neck; it might cause difficulties in the surgery in that region. It may also interfere in invasive techniques.

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