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RESEARCH ARTICLE

The existence of labial SMAS — Anatomical, imaging and histological study

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ABSTRACT

Cutaneous insertion of the facial mimic muscles concerns, at different levels, the superficial fascia of that region. A superficial musculoaponeurotic system is described at face level that facilitates skin insertion of the facial expression muscles through the superficial fascia that acquires particular functional aspects in each region of the face. The existence of a musculofascial system is seen controversial among anatomists, which is why the purpose of this study is to establish its existence at the oral region. The material used in our study consists of twenty-four dissected hemifacies, wherefrom we have recorded images using an operator microscope. Tissue samples have been taken from anatomical specimens examining them by usual staining methods. In parallel, fifteen patients have been investigated with imaging methods (MRI and CT). The results prove the existence of an oral musculoaponeurotic system with a particular organization, similar in the upper and lower part. The superficial fascia disappears into the free margin of the upper and lower lips, as we are emphasizing in the images taken from this level. These findings explain the functional anatomy of this region, but they also form the background of the modern oral plastic surgery.

1. Introduction

It is universally accepted that superficial fascia of the different regions of the body exists and proceeds from one region to another, except the face. In parotid, masseteric and jugal regions its existence is evident, while in the middle regions of the face – nasal and oral – it has been long disputed.

Not long ago (Tessier, 1989) the existence of a morphofunctional cervicofacial system formed by platysma muscles, mimic muscles and superficial cervical and facial fasciae was proposed. At the facial and anterior cervical regions, the superficial fascia does not play a role of separation between superficial muscles and skin, but a role of cohesion and connection between them.

In our previous studies (Francu et al., 2013; Hinganu et al., 2017), we have investigated the disposition of this musculofascial structure in the lateral regions of the face, dissecting and exploring the fixation means for the soft facial structures to the proximal periosteum. We have identified the ligamentary adhesions, ligaments and septa that fix SMAS to the bone, these being the main mechanism of antigravitational support for the soft facial tissues. From this point of view, the existence and particularities of the superficial musculoaponeurotic system plays a crucial role against the phenomenon of "aging face".

We have also identified and researched the morphology and function of SMAS in the Moebius syndrome (Hînganu et al., 2017). Congenital atresia of the facial nerve leads to important functional deficiencies of the perioral muscles which, over time, affect adjacent regions by elongation of fixation means and appearance of superficial soft tissue prolapse. Surgical reconstruction techniques which use the temporal muscle tendon transposition are based on the existence of an oral superficial musculoaponeurotic system.

In the following lines we will approach the oral structures in anatomo-functional terms from a lesser-known perspective: the existence of a unique superficial layer that is closely related to both the skin and subjacent muscular layer.

In support of this theory there are several aspects, such as:

- It explains the functional mechanisms of the facial expression muscles;
- Development of the superficial face and neck muscles and fasciae shows that the development of the facial expression muscles, superficial and profound adipose tissue, facial nerve and parotid

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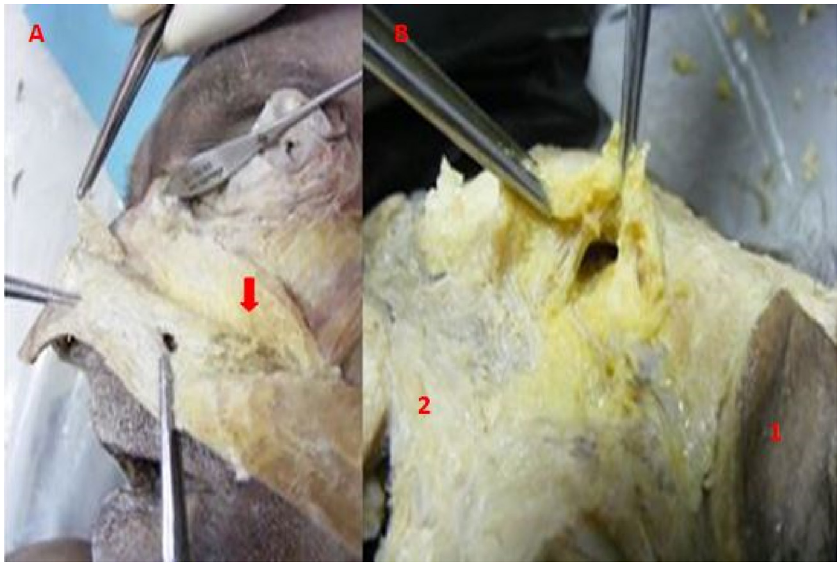

Fig. 1. Connective-adipose tissue from the cheek, prebuccinator and perioral region. Red arrow from picture A points out the examined region from picture B. 1 represents the infraorbital region and 2 the labial commissure. Dissection specimen (SOM 62 KAPS microscope, ×20 oculars), 10/1 scale in the right image. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

gland is the result of some divergent movements and migratory confluences (Standring, 2016), which eventually led to anatomical shaping of a superficial and unique layer at face-level;

- It explains the anatomo-functional mechanisms of the "aging face" phenomenon;
- Nowadays cosmetic surgery would not be possible without SMAS. Old cosmetic surgery techniques, which did not take SMAS into account (or maybe it was not known at that time), could cause downright mutilating scars to patients.

2. Materials and methods

2.1. Macroscopic methods

Our study was carried out on a material consisting of twenty-four dissected hemifacieses formalized and dissected at the Institute of Anatomy "Ion Iancu" within University of Medicine and Pharmacy (U.M.F.) "Grigore T. Popa" Iasi. The macroscopic study on the dissection specimens was performed using the SOM 62 Kaps operator microscope owned by "Ion Iancu" Institute of Anatomy, U.M.F. "Grigore T. Popa" Iasi. The following overlapping layers on the dissection specimens were identified: dermo-epidermic, subcutaneous adipose, superficial fascia, superficial muscular layer, deep fascia, profound musculo-glandular elements and periosteum layer, partially sampled in order to stabilize the fragments. The conclusive aspects taken over by an image acquisition system were subsequently examined and processed to spot regional topographic differences.

2.2. Histological study

With regards to the qualitative micro-anatomical study of SMAS within the topographic pattern of the face, we sampled soft tissues from the oral region, starting from the skin to the bone layout, in the form of small blocks. The sectioning was made perpendicular to the epidermis surface in order to be able to examine the correct sequence of the planes. Sampled fragments were processed using paraffin and H&E stained technique as well as special techniques for connective and muscle tissue (Verhoeff). For stereology technique we used the PRODIT 5.2 program in order to make quantitative measurement of connective and muscular tissue.

2.3. Imagistic study

Our casuistry also included a group of fifteen patients imagistically explored for esthetic surgery purposes or for congenital malformations surgical treatment (Moebius syndrome, congenital facial nerve paralysis) in the Maxillofacial Surgery Clinic within "St. Spiridon" Emergency Clinical Hospital, Iasi — a University based hospital.

MRI is the imaging exploration method that provides the most conclusive images on the cervicofacial soft structures. It is able to demonstrate the stratygraphic anatomy data in detail, obtaining images similar to CT but with a better differentiation of the soft tissues.

3. Results

The oral region has as its main feature, the existence of an infraSMAS space, filled with adipose tissue. This space provides a route of spreading for an infection into neighboring regions.

3.1. Macroscopic study results

The infraSMAS connective tissue from this level contains fibers organized as conjunctive tracts which separate the fat lobules (Fig. 1).

Its structure also includes muscle fibers from the buccinator muscle. Muscle adhesion to the skin through SMAS leads to the conclusion that SMAS actively intervenes in the masticatory act, pulling the skin into the direction of the movements of masticatory muscles (Fig. 2).

Starting from the zygomatic arch and progressing to the mandible, SMAS and infraSMAS tissue are giving the cheek appearance by the amount and shape of the adipose tissue, which they delimit. Here, it also offers skin firmness at the level of the deep planes.

Oral muscles adhere intimately to the deep surface of the skin, crossing the superficial fascia. At this level, in the thickness of the musculoaponeurotic system, there is adipose tissue trabeculated by conjunctive septa and labial vascular nervous structures. The insertion is firm, almost impossible to dissect. Because of this, superficial fascia is extremely difficult to be shown by classic anatomical dis-

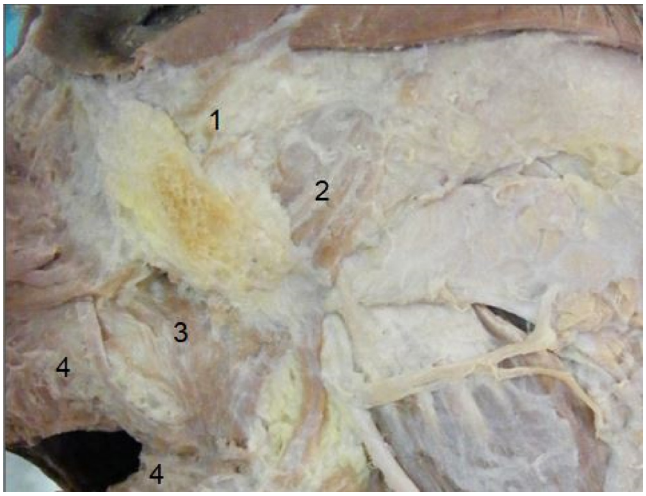

Fig. 2. Muscles of facial expressions at the mouth angle: 1 — zygomaticus minor, 2 — zygomaticus major, 3 — levator anguli oris, 4 orbicularis oris. Dissection specimen (SOM 62 KAPS microscope, ×20 oculars), 3/1 scale.

section (macroscopic). Thus, it is preferred to choose the operator microscope for examination of this region.

We found the continuation of the SMAS with the superficial fascicles of orbicularis oris muscle, suggesting that this layer represents SMAS into superior and inferior lips, separated by the overlying fascial layer (Fig. 3).

We have to emphasize once again the importance of zygomatic ligament, which also contributes to raising the angle of the mouth, applying traction to the superficial fascia of the region. Traumatic injury or its involvement in another pathology may lead to the appearance of some deformities when attempting a facial expression. Its structure is unitary, robust, with connective fibers in its axis (oriented in the superior-medial direction, in the sense of the traction forces vectors acting on it), macroscopically visible. It has two portions: medial (periorbital) and lateral (tragally) (Fig. 4).

Dissecting downward to the lower lip, we have easily revealed a musculo-conjunctival infradermic layer on anterior mandibular surface, which offers attachment for mental muscles.

3.2. Histological assay

Usual staining, specific to connective and muscular tissue, reveals that collagen fibers at this level are thinner, rarefied and placed in disorder, along with more elastic fibers and with muscular fibers longitudinally disposed in the SMAS structure at the upper lip level (Fig. 5).

In regions where the muscular fascicles of orbicularis oris muscle interconnect, we will find collagen fibers with the same longitudinal disposal, from which thin paths descend to the skin (Fig. 6). The conjunctive fibers of SMAS, medial of the nasolabial groove, have longitudinal disposal.

At the angle of the mouth, the numerous collagen fibers lose their fibrous structure making dense clamping strips, which also provide resistance to muscle contraction (Fig. 7). They are inter-

Fig. 3. SMAS at the level of the lips. Red circle in the left picture points out the area of interest, magnified into the right one. The two red circles from the right picture mark the areas of both lips where SMAS ends. Dissection specimen (SOM 62 KAPS microscope, ×20 oculars), 20/1 scale. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

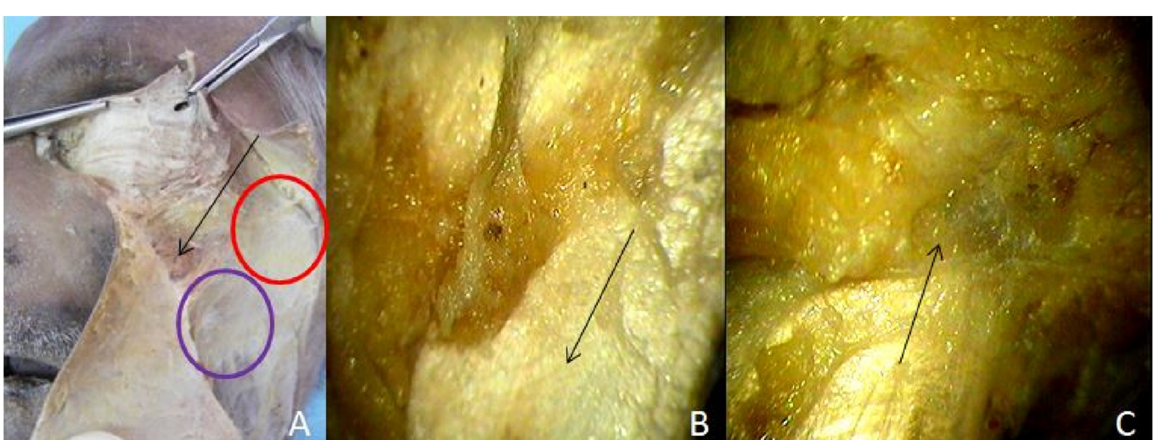

Fig. 4. Image A shows both parts of zygomatic ligament within the two circles. First part, marked by the red circle represents the tragal part, magnified in picture B. The purple circle represents the medial part which adheres on the skin of the cheek, magnified in picture C. The arrow points out the direction of ligamentary fibers, from the zygomatic arch to the cheek in all three pictures. Dissection specimen (SOM 62 KAPS microscope, ×20 oculars), 20/1 scale in B and C images. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

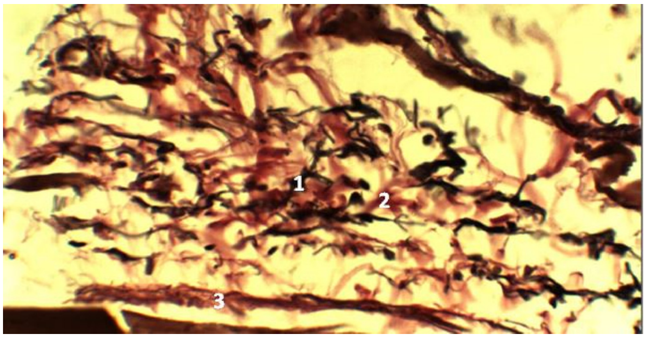

Fig. 5. Thinner collagen fibers (1) and more elastic fibers (2) along with longitudinal muscle fibers (3) in the SMAS structure from the upper lip, middle third level.Col. Verhoeff, ob. 40×.

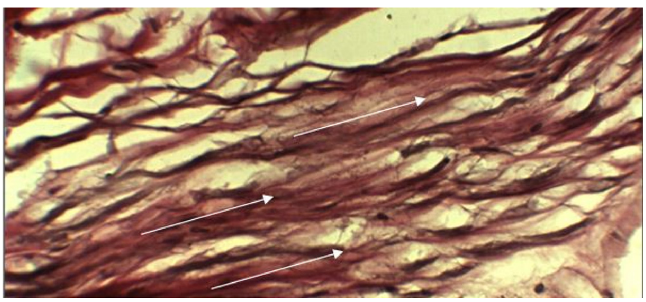

Fig. 6. SMAS medially to nasolabial sulcus with longitudinal disposal of collagen fibers, marked by white arrows. Col. Verhoeff, ob. 40×.

twined with fascicles of muscular fibers, while the elastic fibers are almost absent.

On the lamella stained with Verhoeff's method we quantified the volume percentages of connective tissue, muscular fibers and interstitium compared with the other components, including adipose tissue using.

Quantitative measurements show the following volume percentages quantified by stereological examination of the lamellas:

- connective tissue — 45.56%;
- muscular fibers — 38.15%;
- interstitium — 16.30%.

SMAS cannot be identified in the free margin of lips, both macroscopically and microscopically. Verhoeff staining shows the lack of elastic fibers and the fact that the interstitial tissue prevails.

3.3. MRI results

The MRI images show that above the superior margin of the mandible, the superficial fascia (SMAS) also behaves differently:

a. medially, it gives insertion to the orbicularis oris muscle (inferior fascicle) and then to the depressor anguli oris muscle (Fig. 8);
b. laterally, it becomes mobile, ascending first above the jugal fat pad, buccinator and then the masseter muscle (Fig. 9).

At the upper lip, superficial layers become fixed once again. This happens due to the insertion of the orbicularis oris muscle (superior fascicle) and levator labii superioris on the profound surface of the skin, transfascially.

Even if superficial fascia gets thinner and thinner to modiolus, its thickness is still enough to appear as a clear tissue strip on MRI. The same thing is revealed on dissected specimens.

Ascending to the nasal septum base, the two fasciae (superficial and profound) are united into a dense conjunctive structure. The

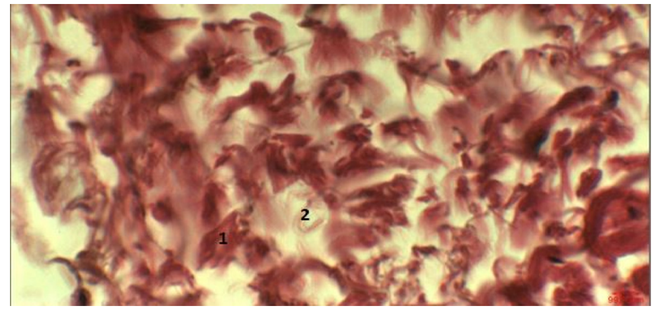

Fig. 7. The SMAS structure at the mouth angle, with many interwoven collagen fibers (1) and with elastic fibers almost absent (2). Col. Verhoeff, ob. 60×.

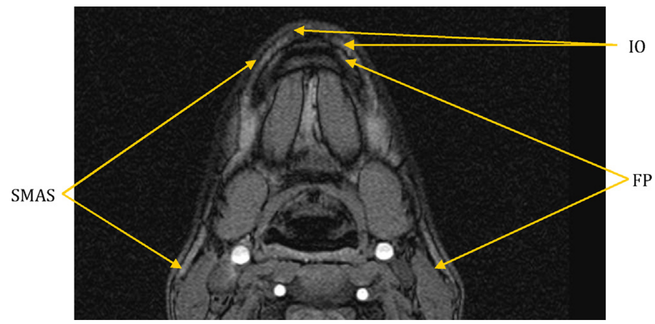

Fig. 8. MRI horizontal section through inferior mandibular margin; SMAS and profound fascia (PF) between parotidian and mental region; TransSMAS insertion of orbicularis oris, inferior fascicle (IO).

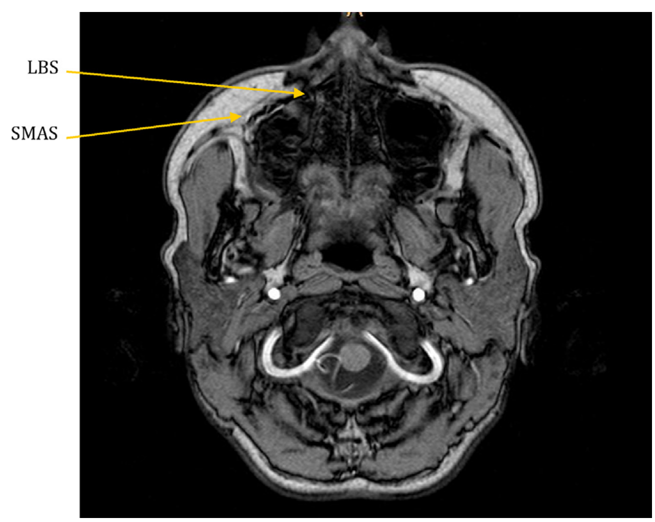

Fig. 9. Transversal MRI which illustrates TransSMAS insertion of levator labii superioris muscle (LBS).

more we are going to the nasolabial groove in its medial part, the clearer the superficial fascia becomes. It provides protection for the superior branch of the angular artery and for superior labial fascicles of the buccal branch from the facial nerve. Injuries of these branches of the facial nerve or of its trunk cause static deformities of this region, alimentation and phonetic disorders, depending on the scale of the injury. These disorders are reflected in the skin insertion of the muscles and the continuity of SMAS toward the other regions that involve their step by step transmission (Fig. 10).

4. Discussions

SMAS relationships with the nasolabial groove are still controversial. Literature studies (Mitz and Peyronie, 1976) described

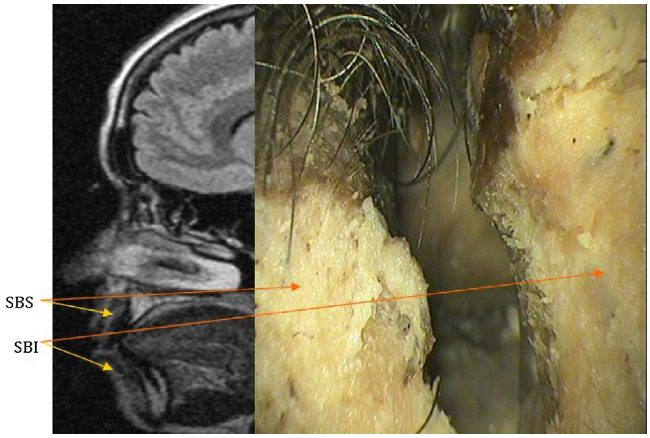

Fig. 10. SMAS at upper lip (SBS) and lower lip (SBI).

anterior continuation of SMAS into the upper lip, overlying the muscular layer. Barton (1992) described a thin fascial layer covering the zygomatic muscles and extending into the upper lip, but they do not identify the subcutaneous extension of SMA. Pensler et al. (1985) distinguished a SMAS layer which is medial to the nasolabial groove, whereas Yousif et al. (1994) consider that there is an adipose supraSMAS layer on the cheek and upper lip.

On the dissected specimens we have identified, starting from superficial to profound, the following layers:

- cutaneous, with a denser profound part, acting for insertion of the facial expression muscles;
- subcutaneous adipose layer;
- superficial facial muscular layer, arranged as follows:
  - *oral region*: zygomatic, rhizorius, orbicularis oris, levator labii superioris, and at the angle of the mouth, modiolus, levator anguli oris and the buccinator;
  - *mental region*: depressor labii inferioris, depressor anguli oris, platysma, mentalis.

This particular SMAS architecture into the oral region is the most important mechanism of support against the "aging face" phenomenon, preventing the occurrence of perioral creases, and downturn of oral commissures (Jeffrey and Posnick, 2015).

Anatomy studies conducted with focus on superficial muscular and fascial structures support the Duchenne's statement of 1862: "*the law governing the expression of the human face can be discovered by studying the action of the muscles*" (Duchenne de Boulogne, 1990).

Surgical techniques of facial rejuvenation and dynamic resuscitation of the oral sphincter are based on the existence of this functional musculoaponeurotic facial system (Pidgeon et al., 2017).

In this context, SMAS, the musculofascial sheath that goes downward the frontal muscle to platysma, plays an essential role, acting as a "**facial muscular contraction amplifier**". In fact, it is a distributor of muscle contraction toward the skin: each muscle contraction follows a preferential direction in the network. An infinite number of actions are possible because, on the one hand, SMAS conveys the contraction of the muscles along the parallel network toward the skin area, and on the other hand it transmits the resulting effect into a perpendicular direction toward the skin through fibrous expansions from SMAS toward the skin. Lifting of the upper lip for facial rejuvenation is based on these features of the regional muscles (Bai-lin, 2017).

SMAS is present in the upper lip and represents the superficial portion of the orbicularis oris muscle but it is not revealed at the free margin of the lips. The main feature of this region is the fixity of the superficial structures to the profound ones. This feature is the basis for the principles of oral facial lifting (Le Louarn et al., 2006; Fogli, 2017). This is caused by strong and flared insertions of the muscles from this level to the profound face of the skin. We can state that it is the real visceral segment of the face. Some oral muscles (orbicularis oris fascicles) play the role of sphincter of the orifice they surround while the others are functional extensions of them.

The more we move toward the midsagittal plane, the thinner the skin becomes. The same disposition is revealed in the subcutaneous adipose tissue, with the mention that the supraSMAS adipose layer is almost non-existent. The superficial and deep fasciae lose their elasticity, being composed of dense connective tissue.

5. Conclusions

Facial SMAS is a unitary structure that fixes the dermis to the facial bones providing a multiligamentary fibrous support system. We showed that oral SMAS exists and facilitates the skin insertion of the oral muscular apparatus. Through SMAS, the oral muscles can exercise their controlled contraction and sphincter function. Zygomatic ligament is the key structure in the dissection process for successful mobilization of the middle part of the face. The facial nerve branches are located between the muscular layer and SMAS. At the upper lip, SMAS has a mixed structure with quite small quantitative differences between the connective and muscular tissue. SMAS is also realizing connective tunnels for the branches of the angular and buccal artery. These anatomical findings could be useful for the understanding of the SMAS concept and when performing various types of facial surgery.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.aanat.2018.04.009

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