SMAS Fusion Zones Determine the Subfascial and Subcutaneous Anatomy of the Human Face: Fascial Spaces, Fat Compartments, and Models of Facial Aging

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Abstract

Background: Fusion zones between superficial fascia and deep fascia have been recognized by surgical anatomists since 1938. Anatomical dissection performed by the author suggested that additional superficial fascia fusion zones exist.

Objectives: A study was performed to evaluate and define fusion zones between the superficial and the deep fascia.

Methods: Dissection of fresh and minimally preserved cadavers was performed using the accepted technique for defining anatomic spaces: dye injection combined with cross-sectional anatomical dissection.

Results: This study identified bilaminar membranes traveling from deep to superficial fascia at consistent locations in all specimens. These membranes exist as fusion zones between superficial and deep fascia, and are referred to as SMAS fusion zones.

Conclusions: Nerves, blood vessels and lymphatics transition between the deep and superficial fascia of the face by traveling along and within these membranes, a construct that provides stability and minimizes shear. Bilaminar subfascial membranes continue into the subcutaneous tissues as unilaminar septa on their way to skin. This three-dimensional lattice of interlocking horizontal, vertical, and oblique membranes defines the anatomic boundaries of the fascial spaces as well as the deep and superficial fat compartments of the face. This information facilitates accurate volume augmentation; helps to avoid facial nerve injury; and provides the conceptual basis for understanding jowls as a manifestation of enlargement of the buccal space that occurs with age.

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Aesthetic procedures often require a basic understanding of fascial layers and how they relate to one another. There is general consensus that there are superficial and deep layers of fascia throughout most of the human body.[1-9] However, the sub-divisions of these layers, the terminology that defines them, and their boundaries have remained a source of controversy throughout medical history.[10-14]

I have identified membranes traveling from deep to superficial fascia during many dissections. These membranes appeared to be bilaminar "fusion zones" that traveled from the superficial to the deep fascia, or the periosteum, and defined the boundaries of the deep fat compartments and anatomic spaces of the face.[15] Therefore, an understanding of these fusion zones as potential boundaries is important for any clinician who performs either volume augmentation or sub-superficial musculoaponeurotic system (SMAS) surgery.

Any discussion of anatomic spaces begins with a review of the buccal fat. Heister first identified the buccal fat in 1732, and his initial interpretation of this tissue as glandular was later corrected by Bichat.[16,17] Studies of how fascia enveloped the buccal fat pad culminated in Ernest Juvara's description of the pterygomaxillary "region," through which he noted the passage of nerves and vascular structures, in 1870.[18-20] Juvara's work, his medical thesis for a doctorate at the Ecole de Médicine in Paris, set a standard for many studies that followed (Figure 1).

Previous descriptions of anatomic spaces always included the anatomical structures contained within these spaces.[21-26] The recognition that spaces served as pathways for the spread of infection provided added impetus for

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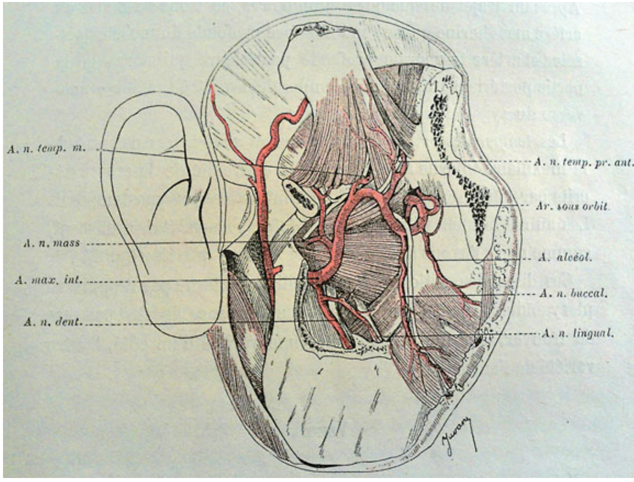

Figure 1. Ernest Juvara is credited with the first description of an anatomic space.[19,20] His doctoral thesis at the Ecole de Médicine in Paris investigated the anatomy of the pterygomaxillary region. Juvara established a standard that future studies would follow when he meticulously defined the structures contained within a space. Reproduced with permission, courtesy of the Francis A. Countway Medical Library (Boston, MA). From: Juvara E. Anatomie de la région ptérygomaxillaire. Thèse no. 186. Baittaille and Cie, Paris, 1895.[20]

work in this field.[7-13,27-30] Grodinsky's treatise on the subject of retropharyngeal abscess includes 84 references, a testament to the frequency of this problem in the pre-antibiotic era.[28]

Basic research conducted by the author in the anatomy laboratory identified bilaminar membranes traveling from the SMAS to the deep fascia or the periosteum. These appeared to partition deep fat into separate compartments and to define the boundaries of the buccal space, forming a construct that has not previously been described in the literature. These observations prompted the present anatomical study.

METHODS

This study used fresh and minimally preserved cadaver specimens.[31] The study included 14 hemifacial cadaver dissections: paired specimens from 4 male subjects and 3 female subjects, with an age range of 42 to 88 years (mean, 60 years). Any specimen that evinced previous facial trauma or surgery was excluded from the study.

Fresh cadaver specimens were dissected within 72 hours of death; minimally preserved specimens were dissected within 48 hours of death. Paired specimens of previously identified deep fat compartments were subjected to two different study methods – one specimen of each pair was injected with dye (tryphan blue; Sigma Aldrich, St. Louis, MO) and cross-sectional dissection was performed on the other specimen of that pair – in order to identify the boundaries of deep fat compartments and anatomic spaces. The anatomy of these boundaries was then further analyzed by macro- and microdissection. Dissection was performed with 4.5 and 6.0 magnification loupes (Design for Vision, Ronkonkoma, NY). For clinical correlation, post-study dissections were conducted on both fresh and minimally-preserved specimens. Photographic documentation was recorded with the Canon 7D system, using a 100 mm macro lens with studio lighting (Canon, Melville, NY). Images were acquired in RAW format, then were converted to TIFF/CMYK and resized in Photoshop (CS 6 version 13.0; Adobe Systems, San Jose, CA).

All dissections were performed by the author in the Willed Body Programs at the University of Louisville School of Medicine and the University of Texas Southwestern Medical School, between January 2013 and August 2014. All study dissections were performed under institutional and federal guidelines for cadaver research. Cadaver research is not considered to be human research requiring institutional review board (IRB) approval at either of the two institutions at which the dissections were performed, unless information about the deceased is Health Insurance Portability and Accountability Act (HIPPA)-protected or used to contact living relatives.[32]

RESULTS

Upon dissection, bilaminar membranes were identified in all the specimens, at consistent locations between the deep fat compartments and at the lateral and medial borders of the buccal space. These bilaminar membranes appeared to be fusion zones between the superficial and deep fascia. These membranes only occurred at the boundaries between adjacent fat compartments, or between fat compartments and anatomic spaces.

Cross-sectional Anatomy in the Axial Plane

Tryphan blue injected into the deep medial cheek fat and the deep lateral fat defined the location and morphology of the SMAS fusion zones (Figure 2). Vertical traction on superficial fascia accentuates the boundary zones of the deep fat compartments.

One distinct boundary zone occurs between the deep lateral fat and the buccal space. The partitioning bilaminar membrane of this zone travels between the deep and the superficial fascia. A major buccal branch of the facial nerve penetrates this bilaminar membrane close to its origin from the superficial fascia and represents a potential site of injury. Another boundary zone occurs medial to the buccal fat, where a bilaminar membrane travels from the superficial to the deep fascia to define the limits of the buccal space and the deep medial cheek fat (Figure 2).

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No dye was observed to bleed along the deep fascia over either the masseter or buccinator muscles, which indicates that the superficial fascia is fused to the deep fascia. In addition, no dye was observed to escape through the superficial fascia into the adipose tissue, validating the injection technique. The observed pattern of dye diffusion defines the morphology of these SMAS fusion zones as confluent membranes.

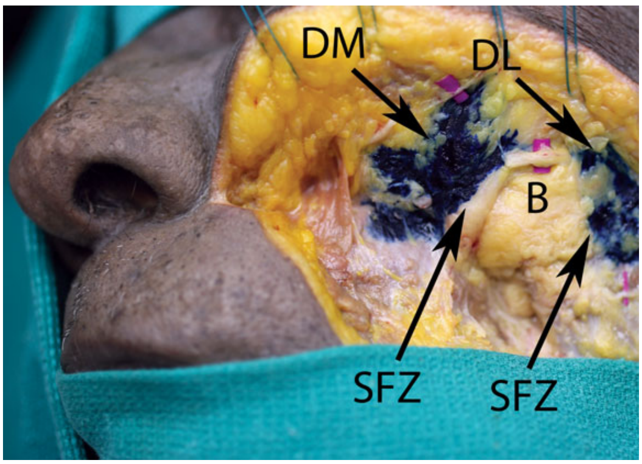

Figure 2. In this specimen from a 68-year-old male, tryphan blue dye injection has defined deep medial fat (DM) and deep lateral fat (DL). Septal membranes travel from the deep to the superficial fascia (sub-superficial musculoaponeurotic system [SMAS] fusion zones, SFZ) and create a closed space. The dye did not stain buccal fat (B) or parotid duct and nerve (beneath violet markers). Green sutures have been placed on the SMAS.

Specimens that had undergone detailed cross-sectional dissections were matched to those that had undergone dye injection. Another axial view is obtained in a specimen from an 88-year-old female (Figure 3A). SMAS fusion zones separating the deep lateral fat from the buccal space and the buccal space from the deep medial cheek fat are identified in this figure. These fusion zones travel from the superficial to the deep fascia. The more medial fusion zone can be seen to originate from the undersurface of the zygomaticus major muscle. These fusion zones exist as bilaminar membranes and often contain a small, intervening fat pad (Figure 3B).

Cross-sectional Anatomy in the Sagittal Plane

Tryphan blue injected into the suborbicularis oculi fat (SOOF) enabled the author to identify a SMAS fusion zone between the intraorbital fat and the SOOF that travels from the superficial fascia to the periosteum; this is the orbicularis retaining ligament (ORL) (Figure 4). A second SMAS fusion zone was observed to define the inferior boundary of the SOOF. These structures are impermeable to dye and exist as confluent membranes.

Once again, specimens that had undergone detailed sagittal cross-sections were matched to those that had undergone dye injection. The three SMAS fusion zones observed in this study are identified in Figure 5. The most superior SMAS

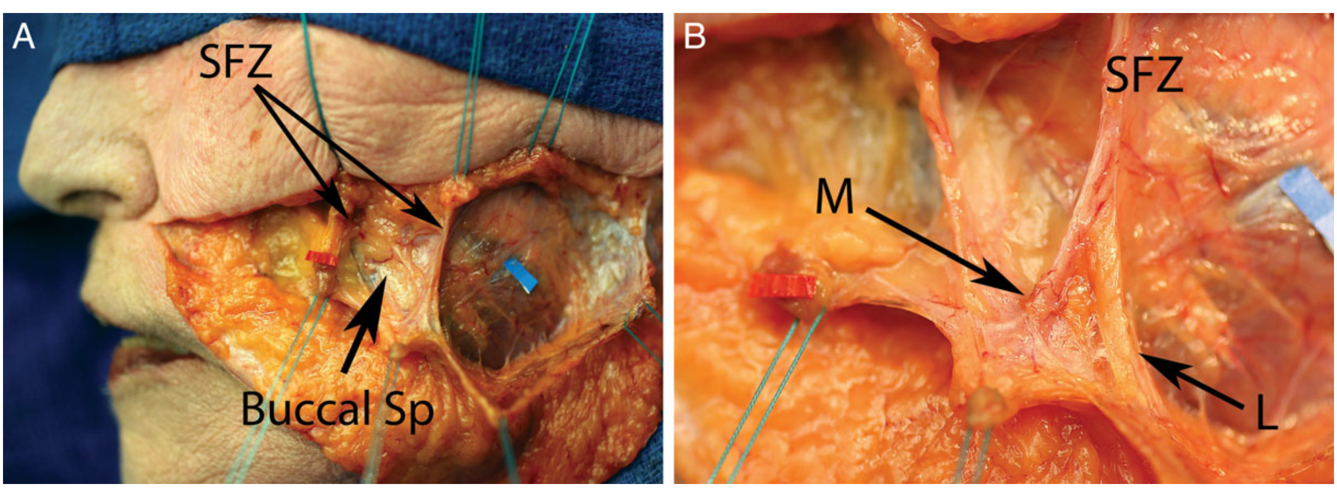

Figure 3. (A) A paired axial dissection was performed on this specimen from an 88-year-old female. The buccal space (Buccal Sp) is defined by septal membranes that travel from the deep to the superficial fascia (sub-superficial musculoaponeurotic system [SMAS] fusion zones, SFZ). The facial nerve is noted within the buccal space. The zygomaticus major muscle lies over the buccal space. (B) Close-up of this specimen illustrates how SMAS fusion zones (SFZ) are formed by medial (M) and lateral (L) leafs of fascia. The intervening fat pad is clearly noted: intervening fat may provide an additional mechanism to prevent shear. There is tremendous redundancy in this biological system (maximizing efficiency): buccal fat is enclosed within fascia, which is, in turn, enclosed by a bilaminar fascial membrane with intervening adipose tissue. Note the small venous plexi ascending from the deep to the superficial fascia along this membrane (upper right), consistent with observations by Juvara in 1895[19] and Scammon in 1919.[21]

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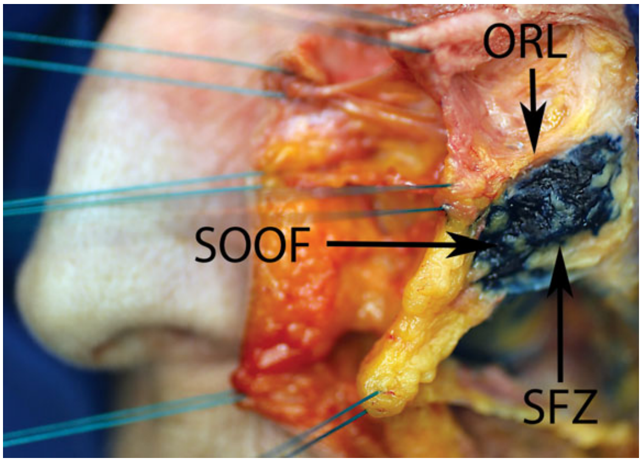

Figure 4. In this specimen from a 72-year-old female, tryphan blue stains the third fat compartment described historically, the suborbicularis oculi fat (SOOF).[34] The orbicularis retaining ligament (ORL) is the sub-superficial musculoaponeurotic system (SMAS) fusion zone that defines the superior boundary of the SOOF; the inferior boundary is defined by a second, transversely oriented SMAS fusion zone (SFZ).

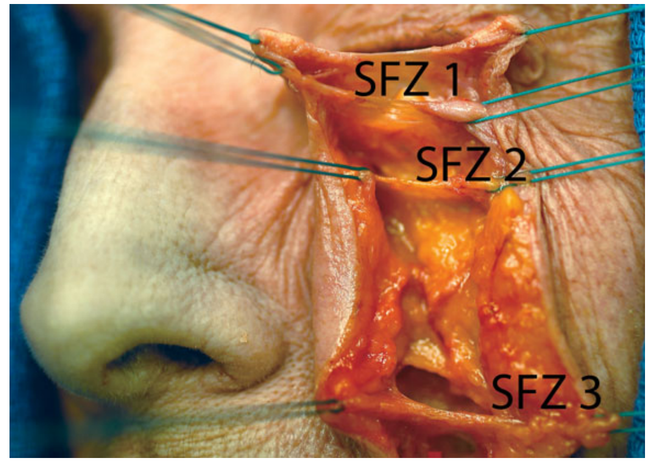

Figure 5. Sagittal dissection of another specimen from an 88-year-old female. The vertical position of SMAS fusion zones in the midface from cephalad to caudad is illustrated: SFZ 1 is the superior boundary of the SOOF, SFZ 2 is the superior boundary of the deep cheek fat, and SFZ 3 is the superior boundary of the deep lip fat. If the reader conceptually merges Figure 5 with Figure 3A, the subfascial anatomy of the human face will be visualized as a series of interlocking myofascial membranes that stabilize vessels, lymphatics, and nerves as they travel between the deep and the superficial fasciae. Gaughran's 1957 description of a transverse septum matches SFZ 3 closely. It remains for scholars to clarify this observation.[12]

fusion zone corresponds to the ORL. This may be dissected as two leafs of fascia originating from the undersurface of the orbicularis oculi muscle. A second SMAS fusion zone occurs inferior to the SOOF. A third SMAS fusion zone occurs between the cheek and upper lip as a boundary zone between the deep cheek fat and the deep lip fat (Figure 5). All the deep fat compartments studied in the present work were found to be defined by these SMAS fusion zones.

The results were consistent among all the specimens studied in the present work. All the SMAS fusion zones identified in this study follow the anatomical construct of fusion between the superficial and the deep fascia (when present) or of fusion between the superficial fascia and the periosteum (when deep fascia is absent).

DISCUSSION

The topic of fascia – specifically, how it divides and fuses to form fascial layers and spaces – has been a source of intense controversy throughout medical history. Confusion over the basic terminology describing fascia led the great anatomist Malgaigne to write, over 200 years ago, that "the cervical fasciae appear in a new form under the pen of each author who attempts to describe them."[35] Misuse of the term "spaces" led Guidera et al, in 2014, to suggest abandoning this term altogether, and replacing it with nomenclature determined by evidence-based anatomic and radiologic findings.[14] I adhere to the Basle Nomina Anatomica (BNA), founded in 1895 to refine the 50,000 names given to only 5000 anatomical structures, for all anatomical descriptions in this article.[36] A detailed review of the literature is provided to avoid redundancy and to show how all of the concepts and ideas discussed herein are dependent on work that has come before.

SMAS Fusion Zones Exist as Bilaminar Membranes

Basic Research

Such is the importance of Grodinsky and Holyoke's work that any discussion of fasciae and fascial spaces is incomplete without it.[33] Published in 1938, their paper is considered by many to be the gold standard for the classification of fasciae as well as for the basic techniques required to identify fascial spaces.[11,12,14]

The term "fusion zone," and the observation that fascial layers may form septal membranes, is not new. Grodinsky and Holyoke noted the apposition of superficial to deep fascia in the neck, most likely at the medial boundary of the submandibular space.[33] Gaughran described a transverse septal barrier at the lateral border of the buccal space in 1957 and referred to it as a fusion zone.[12] It is quite possible that the fusion zone that Gaughran described is analogous to the SMAS fusion zone identified in this study, which is located at

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the boundary between the deep cheek fat and the deep upper lip fat (Figure 5). In 1996, Kikkawa et al described the orbitomalar ligament, a term used interchangeably with "orbicularis retaining ligament" (ORL), as a fascial membrane that travels from the periosteum to the SMAS.[37] Mendelson et al later described this membrane as a bilaminar structure.[38] Gaughran[12] and Kikkawa et al[37] therefore deserve credit for the first descriptions of an SMAS fusion zone.

Building on these authors' line of research, the present study identified four additional bilaminar membranes that travel from the SMAS to the deep fascia or the periosteum (Figures 2-5). The bilaminar nature of these membranes may be related to the fact that investing fasciae, whether superficial or deep, must "split" to contribute a medial and a lateral (or a superior and an inferior) leaf to these membranes.

One of the reviewers suggested employing histology in future research to validate the bilaminar nature of this anatomy. Figure 9 in the study by Muzaffar et al provides an excellent histology sample for this purpose.[39] The authors of this study state that "a discrete orbicularis retaining ligament is not seen."[39] In this sample, the anatomy of the bilaminar membrane is visible, although the sample itself appears to have been badly fragmented by the decalcification process and dehydration (see Figure 9 in the study by Muzaffar et al).[39] If one looks closely at the plexus of vessels visible in the figure directly beneath the orbicularis muscle at the anterior superior orbital rim, a fascial membrane can be seen traveling to the last fenestration of muscle, before it ascends obliquely to insert into dermis. This membrane is clearly the ORL, because it forms the inferior boundary of malar mounds along which a major lymphatic vessel always travels. Directly above the "cu" in "Retinacula," a large, perfectly circular lumen devoid of red blood cells (the main lymphatic channel) can be seen. The SOOF lies beneath this membrane, and, beneath the SOOF, the SMAS fusion zone at the upper boundary of deep cheek fat can be seen, with its accompanying vessels. Finally, at the inferior-most border of the maxilla, the beginning of the SMAS fusion zone that represents the boundary between the deep cheek fat and the deep upper lip fat can be seen.

Hamra, in his discussion of the paper by Mendelson et al, also provides an excellent illustration of these SMAS fusion zones.[38] Hamra clearly illustrates membranes that he has identified traveling between deep and superficial fascia, that he refers to as "the meso-temporalis, meso-zygomaticus, and meso-mandibularis."[37] These are identical to SMAS fusion zones described herein (Figures 2-5).

One may reasonably wonder why, of all the outstanding researchers in the aesthetic surgery field, did Dr Hamra in particular observe these membrane-like structures. During my visit with Dr Hamra in 1993, I asked him to explain his technique of elevating the SMAS with scissors, to which he replied "it's the *vertical spread technique*" (emphasis added). Either in the laboratory or in the operating room, the best way to define the ORL is by *spreading vertically* parallel to the direction it travels. Any SMAS fusion zone will only be correctly identified as a membrane using Hamra's vertical spread technique. The technique of horizontal spreading disrupts their continuity, and leads one to misinterpret these as ligaments rather than as membranes.

Clinical Significance

Routine dissection supports the concept that SMAS fusion zones exist as bilaminar membranes (Figure 6A). It is even possible to inject the intervening fat pads (Figure 6B). This is of academic interest only if it occurs in the laboratory. However, if this occurs in the clinical setting, by volume augmentation along the orbital rim, a firm, discrete, oblong mass is created. This is the so-called "sausage," which is almost impossible to correct, most likely due to the inadvertent injection of the fat pad that lies between the two lamina of the ORL. Understanding the bilaminar nature of these membranes may help avoid this complication. It is also clinically important to understand the relationship of the major lymphatic vessels to the cutaneous insertion of the superficial septae (Figure 6C).

SMAS Fusion Zones Define the Deep Fat Compartments of the Face

Basic Research

Discovering the fat compartments of the face was intuitive and followed a line of research and thinking that had begun decades earlier. Bunnell described the first subcutaneous fat compartment in 1944.[42] In his description of thenar space abscesses, Bunnell noted that "on the dorsum it (infection) is in the *subcutaneous compartment* overlying the first cleft."[42,43] The term "compartment" was likely borrowed from the clinical syndrome (ie, compartment syndrome), itself a controversial topic at the time.[44-46] It is important to acknowledge Bunnell's concept of an anatomic compartment as "a closed fascial space" that may be affected "by edema, extravasation, or hematoma."[43] Other authors continued using the terms "compartment" and "compartmentalized" in reference to a closed fascial system.[12]

Identification of the deep fat compartments of the face followed much later. Owsley described the first deep fat compartment, the sub-muscular upper lid fat, in 1980.[34] Aiache and Ramirez expanded on Owsley's work and coined the term "SOOF," an acronym still used today to describe suborbicularis oculi fat in the lower eyelid.[40]

I identified the first superficial fat compartment of the face, the "superficial cheek fat superior to the cutaneous insertion of the malar septum," in 1992, then published descriptions of this structure in 1997 and 1998.[47-49] At that time, weakening and ptosis of the orbicularis oculi muscle had been suggested as the cause of the "malar crescent."[50,51] Observations and data did not support this suggestion. It did not seem logical that muscles or "ligaments" on the face

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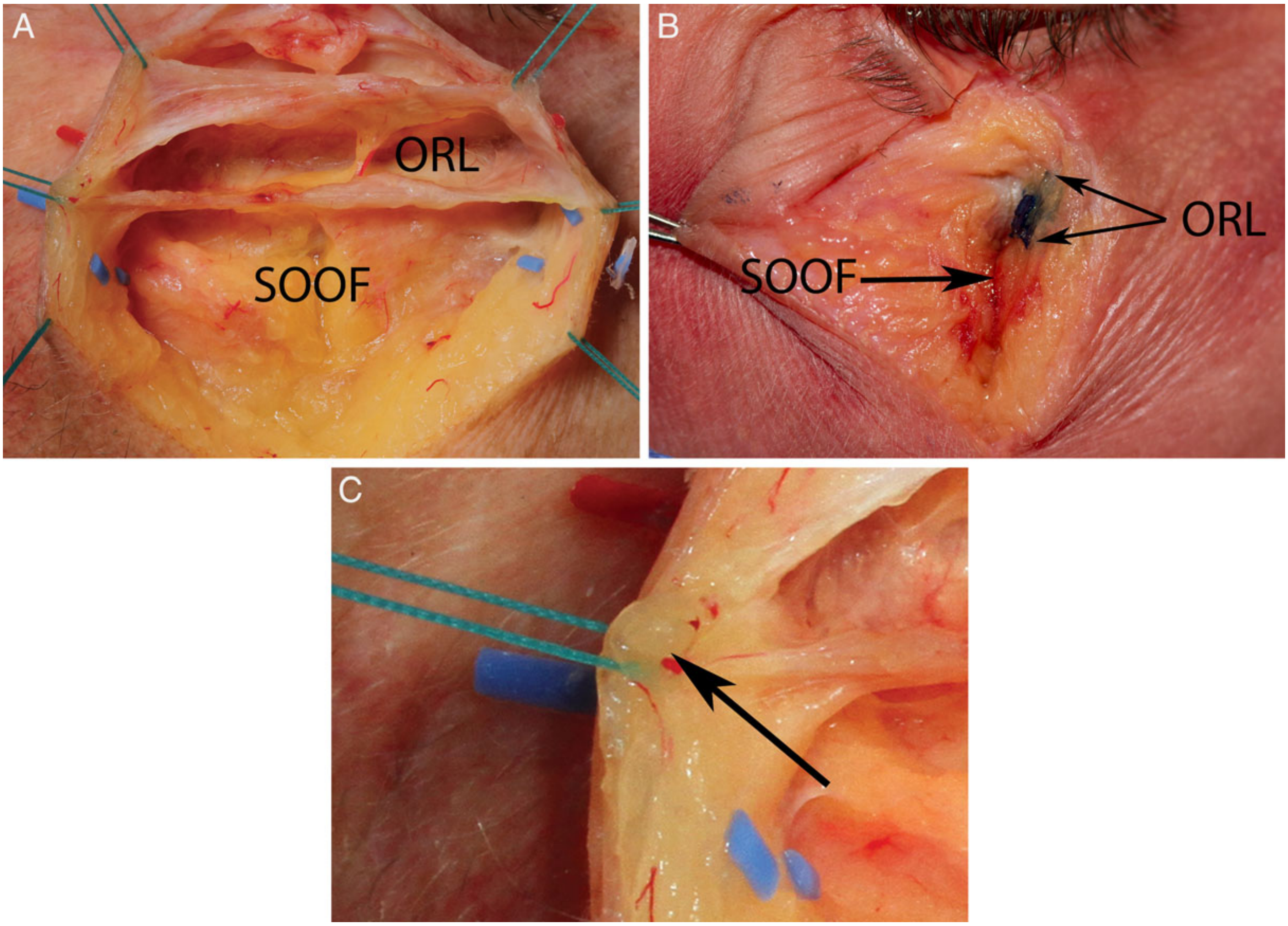

Figure 6. (A) This dissection of a specimen from a 64-year-old male shows an excellent example of the bilaminar nature of sub-superficial musculoaponeurotic system (SMAS) fusion zones. Two leafs of the SMAS form the orbicularis retaining ligament (ORL), the first SMAS fusion zone described on the face by Kikkawa et al.[37] Suborbicularis oculi fat (SOOF) is located directly caudal and deep to the ORL. (B) The fat pad located within the bilaminar ORL is injected with dye in this specimen from a 42-year-old male (blue). The author suggests that injection of filler into the fat pad between the laminae of the ORL may be the mechanism whereby an oblong mass is inadvertently created by forceful injection along the orbital rim. Understanding the bilaminar nature of the SMAS fusion zones can help surgeons avoid this complication. (C) Cropped version of Figure 6A, which shows a tubular structure (arrow) devoid of red blood cells at the cutaneous insertion of the malar septum.[34,41] Molecular biology would likely characterize this structure as a major lymphatic. The orbit cheek crease is the point where orbicularis transitions from the superficial to the deep fascia (see Figure 6A). However, it is important to understand that major lymphatic vessels occur at boundaries between superficial fat compartments.

should become slack with age, because neither behaved that way in other parts of the body. In addition, anatomical dissection had previously shown that the inferior edge of the orbicularis oculi muscle has no relationship to the malar crescent.[38] My critical observation in 1992 suggested that neither laxity nor gravity were the cause of the malar crescent: the inferior boundary of the malar mounds (the lid-cheek junction or nasojugal crease) was constant in young and old individuals alike and was always located 3 cm below the lateral canthus.[47-49] This provided further support for Sichel's concept of recurrent swelling.[52]

In my previous research, I used the term "compartment" to describe the "superficial fat above the cutaneous insertion of malar septum," because this structure satisfied Bunnell's concept of a compartment: an area enclosed by fascia that could expand from edema (blepharochalasis), infection (periorbital cellulitis), or hematoma (periorbital ecchymosis).[42,43,47-49,52] Additionally, I developed the methylene blue dye injection technique based on my observation of periorbital ecchymosis (the methylene blue dye was substituted for hemoglobin pigment).[47-49] Greater access to the anatomy laboratory facilitated my description

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of additional compartments (published with co-author, Rohrich) in 2007.[53]

It was not by chance that the first superficial fat compartment of the face to be described was in the lower eyelid.[47-49] Clinical observation of periorbital ecchymosis suggested that the lower eyelid is a discrete region of adipose tissue. However, every other area of the face is similarly prone to hematoma and ecchymosis, so why is ecchymosis only apparent in the lower eyelid? The answer is simple (in retrospect): dermis is more impermeable to hemoglobin breakdown products than the membranes that partition superficial fat compartments. By the time an ecchymosis is evident on the cheek, chin, or neck, hemoglobin breakdown products have diffused into adjacent compartments. Only in a compartment covered by extremely thin dermis will ecchymosis be observed as having discrete boundaries.[34,40,47-49] This explains why the current map of fat compartments in the face is, at best, preliminary.[53] Superior dyes and improved techniques are available today that can almost certainly refine the results of many earlier studies.[54]

The present study adds to the existing body of knowledge by suggesting that bilaminar membranes traveling from the superficial to the deep fascia partition the deep fat into discrete compartments. These membranes help stabilize blood vessels, lymphatics, and nerves and are referred to as septa, in keeping with the terminology (eg, septum orbitale) accepted by the BNA.[32] A rudimentary model of the compartmentalization of subcutaneous fat, which originated from Bunnell's initial observations, thus begins to emerge.[42,43]

Fusion zones between the deep fascia and the SMAS (or the periosteum and the SMAS) are the primary structures that determine the location of all the fat compartments of the face.[41,47-49] The bilaminar subfascial membranes that make up these fusion zones continue into the subcutaneous tissue as unilaminar septae, to insert into skin. Nerves, vessels, and lymphatics travel along and within the SMAS fusion zones, which help stabilize and protect these delicate structures from motion and shearing. The cutaneous insertion of SMAS fusion zones coincides with major lymphatic vessels.[55] Creases form directly over major lymphatic vessels, arteries, and veins from decades of repetitive muscular contractions.[54,55]

Facial aging does not cause laxity or stretch of the SMAS fusion zones unless stress attenuation occurs. However, recurrent inflammation may lead to shortening of these membranes, which ultimately tether the skin at their cutaneous insertion points. Chronic buccal space infection is an excellent model for the effects of inflammation on SMAS fusion zones: computerized tomography (CT) scans of the affected area show how a shortened membrane tethers skin at the medial border of the buccal space.[56] Low-grade, chronic inflammation may modulate how an SMAS fusion zones responds to aging. Stress attenuation of SMAS fusion zones is discussed in the next section.

Clinical Significance

SOOF augmentation is a useful technique to efface suborbital hollowing.[57,58] The boundaries of the SOOF are defined by the present study as transversely oriented SMAS fusion zones. Knowing the location of these boundaries improves precision during SOOF augmentation. In addition, the superior boundary of the SOOF partitions it from the intraorbital space and fat.

Understanding the specific anatomy of this SMAS fusion zone can help prevent inadvertent intraorbital and buccal space injection. The boundary between the deep cheek fat and the buccal space is a vertically-oriented SMAS fusion zone (Figure 3). This fusion zone arises just lateral to the zygomaticus major muscle and lateral to the medial border of the masseter muscle. It is critical to understand this anatomy when performing deep cheek fat augmentation. If the clinician asks the patient to smile, gentle palpation of the cheek tissues will identify the contraction of the zygomaticus major muscle. The trajectory of the injection needle must be oblique and medial; otherwise, augmentation of the buccal space will occur. Inadvertent buccal space injection can be identified immediately by the clinician because it increases the prominence of the jowl.

There is no convincing research at the present time to suggest that aging affects any superficial compartment differently than another. The manner in which the fat compartments of the face are defined by SMAS fusion zones suggest that they have similar biological properties. The primary function of partitioning membranes is to stabilize vessels, lymphatics, and nerves; one secondary function is that these partitioning membranes *arbitrarily* divide the superficial and deep fat into compartments. Regional differences in blood supply to these compartments are minor: it is suggested that lymphatic dysregulation, either iatrogenic or as a result of disease, is a more likely cause of any regional differences observed with aging. For this reason, it is critical to avoid damaging the major lymphatic channels that travel along the borders of fat compartments.[55]

SMAS Fusion Zones Delimit Anatomic Spaces

Basic Research

The present study identifies bilaminar membranes traveling from the deep to the superficial fascia, serving as the boundaries of the buccal space (Figures 2 and 3A). This fascial space contains the buccal fat pad enclosed within its own fascia (Figure 7). These are referred to as fusion zones, in keeping with the terminology used by Gaughran[12] and Grodinsky and Holyoke.[33]

Some of the most comprehensive studies of facial anatomy performed over the last 150 years address the topic of anatomic spaces. Collier and Yglesias,[19] Juvara,[33] and Grodinsky and Holyoke[59] stand out as masterpieces of

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research in this field. These authors' definitions of spaces agree with one another. Grodinsky and Holyoke provided the gold standard in technique required to identify fascial spaces: dye injection and cross-sectional anatomy.[33] The published literature establishes three criteria that must be fulfilled to define an anatomic space: (1) a space contains well-defined anatomic structures, (2) a space acts as a pathway for the spread of infection, and (3) a space, even if it exists only as a *potential* space, must have the capacity to expand and become a *true* space in the presence of edema, infection, or hematoma.[19-30,33,42,43,52] The term "space" is a meaningful one for clinicians, because it suggests the path of an infection, the most appropriate location for surgical drainage, as well as the structures at risk during surgery.

Misuse, and misapplication, of the term "space" has led some authors to recommend abandoning this term altogether and replacing it with the word "compartment."[14] However, even this terminological substitution leads to confusion. A fat "compartment" is defined as a region of adipose tissue confined within a relatively impermeable membrane (the septum).[41-43,47-49] Anatomical spaces are defined by fusion zones between superficial and deep fascia and may contain adipose tissue that is, itself, further circumscribed by fascia, as suggested by Scammon.[21]

Recently, Mendelson et al have described a premasseteric space.[60] Mendelson et al have suggested that this "space," being devoid of branches of the facial nerve, offers a safe plane of dissection during facelift procedures. A short preface is needed before continuing. It was suggested to me multiple times during this study that the concept of "spaces" as discussed herein be compared directly with Mendelson et al's research. I have the greatest respect for the work by Mendelson's group; their commitment to excellence is obvious to anyone who has spent long hours in the anatomy laboratory. However, the terms "dissection plane" or "cleavage plane" are more appropriate than terming this structure the premasseteric "space."[61]

The word "space" has been used interchangeably with "cleavage plane" and "glide plane" in several articles by Mendelson's group.[38,39] A review of the literature has established that three criteria that must be fulfilled in order to define an anatomic space (see previous discussion as well as Table 1).[18-30,33,59] This is in direct contrast to "dissection" or "cleavage" planes, which have the following characteristics: (1) they are devoid of well-defined anatomical structures (thus serving as planes for surgical dissection), (2) they are not observed to serve as pathways for infection, and (3) they do not become true spaces and expand *unless surgically altered* (see Table 1). Mendelson et al even state that "the prezygomatic space is an entity, even though it may require dissection to be revealed."[38] I made a similar error when I suggested using the term "Ristow's Space" for the supraperiosteal area beneath the deep medial cheek fat, which was described by Rohrich et al.[62] It is more appropriate to refer to this structure as a "dissection plane," because it does not satisfy any of the three accepted criteria of an anatomic space (Table 1). (Changing the name in no way detracts from Ristow's brilliance in augmenting this area to improve cheek projection.[62])

An even easier way to distinguish anatomic spaces from dissection planes is to consider their functions (Table 1). Two opposing fascial systems – the masseteric fascia and

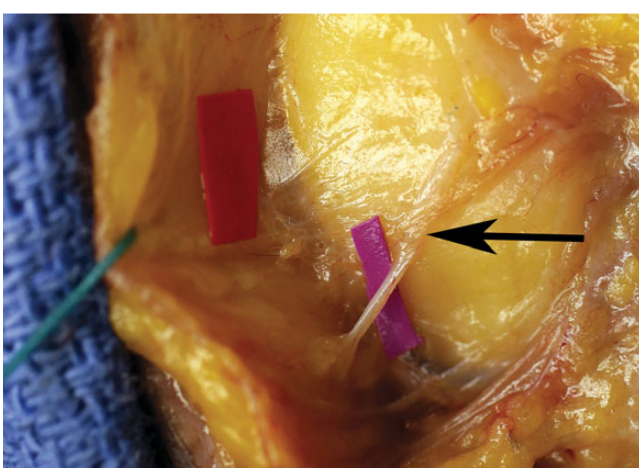

Figure 7. Dissection of a specimen from a 79-year-old female that shows how the facial nerve travels *through* the buccal space: beneath the fascia of the buccal space but above the fascia enclosing the buccal fat pad (arrow). The sub-superficial musculoaponeurotic system (SMAS) (red marker is on the undersurface of the SMAS) fuses with the fascia of the buccal space.

Table 1. Anatomic Spaces, Dissection Planes, and Fat Compartments

Criteria	Spaces	Dissection planes	Fat compartments
Contain defined structures	Yes	No	Variable
Pathways for infection	Yes	No	No
Expand in vivo	Yes	No	Yes
Play a role in facial aging	Yes	No	Yes
Function	Protect structures from shear, infection	Gliding, isolate muscular contraction	May contain infection

Anatomic spaces can be differentiated from dissection planes and fat compartments based on 5 criteria: (1) the presence or absence of defined structures, (2) the ability to serve as pathways for the spread of infection, (3) the capacity to expand in vivo, (4) whether they play a role in facial aging, and (5) their possible function. Strict adherence to the first three of these criteria avoids much of the confusion that exists in the literature about the differences between anatomic spaces, dissection planes, and fat compartments.

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the SMAS allows for shear and facilitates tissue gliding. This allows for shearing with no risk of damage to important structures, which is notably absent. Muscular contraction of the masseter muscle is therefore *isolated*, which is why it is not considered a muscle of facial expression. The SMAS can move over the masseter muscle because it lacks any fibrous membranes.

The dissections performed by Mendelson's team were brilliantly done, their concepts were well-thought-out and provocative, and their commitment and enthusiasm is without parallel. I only disagree with their terminology, based on the literature review I conducted.

Clinical Significance

The concept of bilaminar SMAS fusion zones representing the boundaries of anatomic spaces supplies the clinician with valuable, practical information. Understanding that the facial nerve transitions from the deep to the superficial fascia through SMAS fusion zones can help prevent nerve injury during surgery (Figure 7).[63] Much of the literature attempting to describe safe and "danger" zones for dissection as well as planes is overwhelmingly tedious and complicated. A simple and perhaps intuitive way to think about the course of the facial nerve is described below.

Branches of the facial nerve travel as deep as possible until they reach the edge of the muscles they innervate. They leave this protected course when they transition from the deep to the superficial fascia. To minimize the risk of injury, nerves transition as close to muscle as possible and also travel along and within stabilizing membranes. The buccal branch of the facial nerve is most often injured at the superior border of the zygomaticus major muscle (the transition point along the SMAS fusion zone). The frontal branch of the facial nerve is most often injured at the inferior border of the frontalis muscles (along a temporal SMAS fusion zone). Injury to the marginal mandibular nerve and zygomatic branch occur in a similar manner. If a surgeon knows the location of the SMAS fusion zones, the course of all of the facial nerve branches, from the deep to the superficial fascia, can be anticipated and, thus, avoided.

This anatomy suggests the utility of SMAS undermining. I consider Stuzin's technique of the extended SMAS to be as brilliant as it is intuitive.[64] An inherent goal of Stuzin's technique is the creation of a "submalar hollow." A submalar hollow is created by increasing anterior cheek projection and diminishing the jowl. I spent time in the anatomy laboratory devising a tilt test to analyze the motion of the buccal fat, only to find out later that a quicker and more experienced mind had gotten there first.[65] Owsley suggested that changing a patient's position from upright to supine with the chin slightly everted corrects cheek projection, improves the "v deformity," and corrects the jowl. This is the same correction that Stuzin attempted to make with his extended SMAS.[64] Owsley even mentions the cascade or chain of events that occurs during this positional change: as the jowl diminishes, anterior cheek projection increases, a submalar hollow forms, and the topography of the lower eyelid is improved.[65] The only adipose tissue in the human face that is capable of this degree of mobility is the buccal fat, enclosed within a gliding fascia. Odontogenic infections of the buccal space *accentuate* the jowl, masses and hematoma within the buccal space *mimic* the jowl, and inadvertent filler augmentation of the buccal space *creates* a jowl. The jowl is a manifestation of enlargement of the buccal space that occurs with age due to stress imposed on the SMAS fusion zone by repetitive contraction of the masseter muscle.

Removing buccal fat to improve the jowl leads to iatrogenic wrinkling over time (Ryuichi Utsugi. Personal communication, 2010). I suggest that SMAS dissection that includes division of the lateral SMAS fusion zone effectively decreases buccal space volume and is one solution to correct jowls. This concept involves no lifting effect via SMAS work or the rhytidectomy procedure. Where the surgeon initiates the SMAS dissection laterally is irrelevant: only the medial extent of the dissection matters, the goal being division of the SMAS fusion zone that defines the buccal space. Others have described SMAS undermining into the buccal space, along with lateral transposition of the buccal fat, to further diminish the jowl and to increase anterior cheek projection.[66] It is likely that reducing buccal space volume by dividing the SMAS fusion zone would occur as a result of employing this technique. There is even precedence in the literature for this concept: implicit in the septal reset procedure is division of an SMAS fusion zone (the ORL) and intraorbital fat transposition.[67,68] Conceptually, the septal reset does no "lifting"; it decreases orbital space volume and improves surface topography by transposing fat. Decreasing buccal space volume by dividing an SMAS fusion zone and by SMAS manipulation obviates the need to generate tension on the skin flap, which only acts as a sheet pulled tightly over a pillow, as suggested by Millard.[69]

Future Studies

In the field of anatomical research, many consider the fascia and its derivatives to represent the greatest research challenge.[19,20,33,56] It is fortunate that both historic techniques and current technologies offer the surgical anatomist superb tools to meet this challenge.

Grodinsky and Holyoke established the gold standard for investigating fasciae: dye injection combined with cross-sectional anatomical dissection.[33] It is natural for a researcher transitioning from the operating room to the anatomy laboratory to utilize routine surgical techniques for dissection, techniques that have absolute limitations imposed by ethical standards and time. Careful, layered dissection is mandatory for successful surgical outcomes. The anatomy laboratory holds no such limitations. A cursory perusal of anatomic

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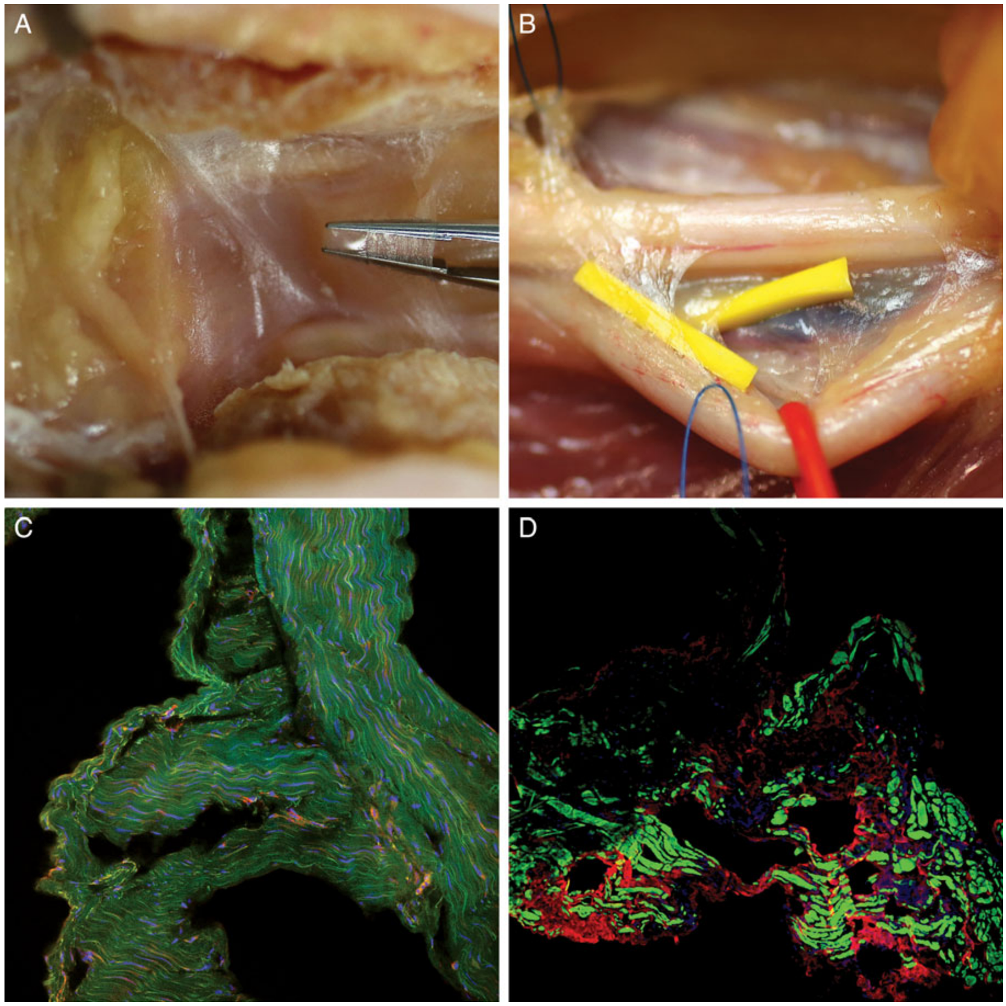

Figure 8. (A) A section of a peritendinous sheath from a specimen from a 71-year-old female (beneath forceps). It is difficult to characterize the various fasciae based on their appearance or histology. (B) A neurovascular sheath from the same specimen has a similar appearance (beneath yellow marker). (C) Indirect immunohistochemistry of the peritendinous sheath results in minimal fluorescence to antimuscle antibodies conjugated to fluorescent dye. Images were obtained with the Zeiss SP 5 confocal laser microscope. Primary antibodies were anti-F actin and antimysoin 2B; secondary antibodies were goat antimouse IgG (H + L) alexa fluor 488 (Life Technologies, Grand Island, NY) and goat antirabbit F(ab')2 IgG (H + L) alexa fluor™ 594. (D) Immunohistochemistry of the neurovascular sheath reveals bright fluorescence to antimuscle antibodies, suggesting the potential for muscular contraction. Preliminary work suggests that the sub-superficial musculoaponeurotic system (SMAS) and its derivatives have a similar nature. Molecular biology may provide the ability to characterize and define the various fasciae according to their biological functions.

texts shows the immense value provided by dissecting in multiple planes. In concert with dye injection, arterial/venous/lymphatic injection, and fluorescent technology, cross-sectional anatomical dissection provides a means to investigate the various fasciae in the finest detail.

Controversy will continue to surround any discussion of these complex tissues until methods exist for characterizing them definitively. Molecular biology has been a tremendous benefit to plastic surgeons. The mechanism of scar contracture, a classification of vascular anomalies, and the anatomical basis for wrinkles all relied on molecular biology techniques.[55,70,71] The peritendinous sheath and the neurovascular sheath appear identical in the same individual (Figure 8A,B). However, the difference in their biology is apparent with the application of direct immunohistochemistry (Figure 8C,D). Preliminary work suggests that the SMAS and its derivatives are *myofascial* in nature. The application of molecular biology may therefore hold the greatest promise to definitively characterize the various fasciae.

CONCLUSIONS

A construct of subfascial anatomy and its possible clinical relevance is described herein. SMAS fusion zones exist as

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bilaminar membranes, travel from the deep to the superficial fascia, and determine the anatomic boundaries of the fat compartments and anatomic spaces. The clinical observations, prior research, and anatomical dissections that led to these concepts are presented in detail for the reader to analyze. It is my hope that this work will stimulate additional research in this area of anatomy and as well as in the area of facial aging.

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REFERENCES

1. Davidge KM, van Furth WR, Agur A, Cusimano M. Naming the soft tissue layers of the temporoparietal region: unifying anatomic terminology across surgical disciplines. *Neurosurg*. 2010;67:120-129.
2. de Vasconcellos JJ, Britto JA, Henin D, Vacher C. The fascial planes of the temple and face: an en-bloc anatomical study and pleas for consistency. *Br J Plast Surg.* 2003;56 (7):623-629.
3. Tellioglu AT, Tekdemir I, Erdemli EA, Tuccar E, Ulusoy G. Temporoparietal fascia: an anatomic and histologic reinvestigation with new potential clinical applications. *Plast Reconstr Surg.* 2000;105(1):40-45.
4. Thaller SR, Kim S, Patterson H, Wildman M, Daniller A. The submuscular aponeurotic system (SMAS): a histologic and comparative anatomy evaluation. *Plast Reconstr Surg.* 1990;86(4):690-696.
5. Abu-Hijleh MF, Roshier AL, Al-Shboul Q, Dharap AS, Harris PF. The membranous layer of superficial fascia: evidence for its widespread distribution in the body. *Surg Radiol Anat*. 2006;28:606-619.
6. Lettieri S. Frontal branch of the facial nerve: galeal temporal relationship. *Aesthet Surg J.* 2008;28(2):143-146.
7. Lindner HH. The anatomy of the fasciae of the face and neck with particular reference to the spread and treatment of intraoral infections (Ludwig's) that have progressed into adjacent fascial spaces. *Ann Surg*. 1986;204(6):705-714.
8. Gosain AK, Yousif NJ, Madiedo G, Larson DL, Matloub HSSanger JR. Surgical anatomy of the SMAS: a reinvestigation. *Plast Reconstr Surg*. 1993;92:1254-1263.
9. Mitz V, Peyronie M. The superficial musculoaponeurotic system (SMAS) in the parotid and cheek area. *Plast Reconstr Surg*. 1976;58:80-88.
10. Accioli de Vasconcellos JJ, Britto JA, Henin D, Vacher C. The fascial planes of the temple and face: an en-bloc anatomical study and a plea for consistency. *Br J Plast Surg.* 2003;56(7):623-629.
11. Granite EL. Anatomic considerations in infections of the face and neck: review of the literature. *J Oral Surg*. 1976; 34:34-44.
12. Gaughran GRL. Fasciae of the masticator space. *Anat Rec*. 1957;129(4):383-400.
13. Barnaby-Zachary GM. The sub-masseteric space. *Brit Dent J.* 1948;84:10-13.
14. Guidera AK, Dawers PJD, Fong A, Stringer MD. Head and neck fascia and compartments: no space for spaces. *Head Neck*. 2014;36:1058-1068. doi:10.1002/hed.23442.
15. Mitz V, Peyronie M. The superficial musculo-aponeurotic system (SMAS) in the parotid and cheek area. *Plast Reconstr Surg.* 1976;58(1):80-88.
16. Heister L. *Compendium Anatomicum*. Norimbergae, 1732.
17. Bichat FMX. *Anatomie générale*. Paris, 1801.
18. Burns A. *Observations on the chirurgical anatomy of the head and neck*. Edinburgh, 1821.
19. Juvara E. Anatomie de la région ptérygomaxillaire. Theses, Paris, 1870.
20. Juvara E. Anatomie de la région ptérygomaxillaire. Thèse no. 186. Baittaille and Cie, Paris, 1895.
21. Scammon RE. On the development and finer structure of the corpus adiposum buccae. *Anat Rec.* 1919;15:267-287.
22. Kostrubala JB. On the potential spaces in the face. *Am J Surg.* 1945;68:28-37.
23. Work WP. Abscess of pterygomaxillary space following acute suppurative sinusitis; a case report. *Laryngoscope*. 1948;58(12):1318-1323.
24. Calcaterra VE, Karmody CS. Infections of the masseteric space in children. *Otolaryngol Head Neck Surg.* 1984;92 (1):188-122.
25. Rodgers GK, Myer EN. Surgical management of the mass in the buccal space. *Laryngoscope*. 1988;98(7): 749-753.
26. Meiselman F, Cuttino CL. A large submandibular space mass. *J Oral Maxillofac Surg*. 1990;48(1):63-67.
27. Holt EE. Orbital cellulitis: the inflammation spreading to the temporal region, and to the brain, causing death, with reports of five other cases. *Trans Am Ophthalmol Soc.* 1892;6:295-306.
28. Grodinsky M. Retropharyngeal and lateral pharyngeal abscesses. *Ann Surg*. 1939;110(2):177-199.
29. Bell RH. The clinical importance of the surgical anatomic spaces of the head and neck. *Oral Surg Oral Med Oral Pathol*. 1958;11(4):339-354.
30. Johnson JJ, Tucker HM. Recognizing and treating deep neck infection. *Postgrad Med*. 1976;59(6):95-100.
31. Anderson SJ. Practical light embalming technique for use in the surgical fresh tissue dissection laboratory. *Clin Anat*. 2006;19:8-11.

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32. Pentz RD, Cohen CB, Wiccliar M, et al. Ethics guidelines for research with the recently dead. *Nat Med*. 2005;11(11):1145-1149.
33. Grodinsky M, Holyoke EA. The fasciae and fascial spaces of the head, neck and adjacent regions. *Am J Anat*. 1938;63:367-407.
34. Owsley JQ. Resection of the prominent lateral fat pad during upper lid blepharoplasty. *Plast Reconstr Surg* 1980;65(1):4-9.
35. Malgaigne J. *Traité d'anatomie chirurgicale*. Paris: JB Balliere, 1838.
36. Eycleshymer AC. *Anatomical Names*. New York: William Wood and Co., 1917.
37. Kikkawa DO, Lemke BN, Dortzbach RT. Relations of the superficial musculoaponeurotic system to the orbit and characterization of the orbitomalar ligament. *Ophthal Plast Reconstr Surg*. 1996;12:77-88.
38. Mendelson BC, Muzaffar AR, Adams WP Jr. Surgical anatomy of the midcheek and malar mounds. *Plast Reconstr Surg* 2002;110(3):885-896. Discussion by Hamra ST, pages 900–904.
39. Muzaffar AT, Mendelson BC, Adams WP Jr. Surgical anatomy of the ligamentous attachments of the lower lid and lateral canthus. *Plast Reconstr Surg*. 2002;110(3):873-884.
40. Aiache AE, Ramirez OH. The suborbicularis oculi fat pads: an anatomic and clinical study. *Plast Reconstr Surg*. 1995;95:37-42.
41. Scheverian MV, Pessa JE, Rohrich RJ. Vascularized membranes determine the anatomical boundaries of the subcutaneous fat compartments. *Plast Reconstr Surg*. 2009;123(2):695-700.
42. Bunnell S. *Surgery of the Hand*. Philadelphia: Lippincott Company, 1944.
43. Bunnell S. *Bunnell's Surgery of the Hand*. 4th ed. Revised by Boyes JH. Philadelphia and Montreal: J.B. Lippincott Company, 1964.
44. Bunnell S, Doherty EW, Curtis EM. Ischemic contracture, local, in the hand. *Plast Reconstr Surg*. 1948;3(4):424-433.
45. Foisie PS. Traumatic arterial vasospasm. *N Engl J Med*. 1947;237(9):295-302.
46. Seddon HJ. Volkmann's Contracture: Treatment by excision of the infarct. *J Bone Joint Surg*. 1956;38-B(1):152-174.
47. Pessa JE. The malar septum: the anatomical basis of malar mounds and malar edema. In: Presented at the 1992 Aesthetic Surgery Meeting, Los Angeles, California. Tiffany Award Paper.
48. Pessa JE, Garza JR. The malar septum: the anatomical basis of malar mounds and malar edema. *Aesthet Surg J*. 1997;17(1):11-17.
49. Pessa JE, Zadoo VP, Adrian EK, Woodwards R, Garza JR. Anatomy of a 'black eye': a newly described fascial system of the lower eyelid. *Clin Anat* 1998;11(3):157-161.
50. Hamra ST. Composite Rhytidectomy. *Plast Reconstr Surg*. 1992;90(1):1-13.
51. Hamra ST. Prevention and correction of the 'face lifted' appearance. *Facial Plast Surg*. 2000;16(3):215-225.
52. Sichel A. Ann d'ocul 1844;12:188.
53. Rohrich RJ, Pessa JE. The fat compartments of the face: anatomy and clinical implications for cosmetic surgery. *Plast Reconstr Surg*. 2007;119(7):2219-2227.
54. Pessa JE, Rohrich RJ. *Facial Topography*. St. Louis: Quality Medical Publishing, 2012.
55. Pessa JE, Nguyen H, John GB, Scherer PE. The anatomical basis for wrinkles. *Aesthet Surg J*. 2014;34(2):227-234.
56. Mills CC, Amin M, Manisali M. Salivary duct fistula and recurrent buccal space infection: a complication of Crohn's disease. *J Oral Maxillofac Surg*. 2003;61:1485-1487.
57. Massry GG, Azizzadeh B. Periorbital fat grafting. *Facial Plast Surg*. 2013;29:46-57.
58. Tonnard PL, Verpaele AM, Zeltzer AA. Augmentation blepharoplasty: a review of 500 consecutive patients. *Aesthet Surg J*. 2013;33:341-352.
59. Coller FA, Yglesias L. Infections of the lip and face. *Surg Gyn Obstet*. 1935;60:277-290.
60. Mendelson BC, Freeman ME, Woffles W, Huggins RJ. Surgical anatomy of the lower face: the premasseter space, the jowl, and the labiomandibular fold. *Aesthetic Plast Surg*. 2008;32:185-195.
61. Snitman MF, Soboroff BJ. Planes of surgical dissection of the neck. *Ann Otol Rhinol Laryngol*. 1951;60(3):881-882.
62. Rohrich RJ, Pessa JE, Ristow B. The youthful cheek and the deep medial fat compartment. *Plast Reconstr Surg*. 2008;121(6):2107-2112. doi:10.1097/PRS.0b013e31817123c6.
63. Daane SP, Owsley JQ. Incidence of cervical branch injury with "marginal mandibular nerve pseudo-paralysis" in patients undergoing face lift. *Plast Reconstr Surg*. 2003;111(7):2414-2418.
64. Stuzin JM, Baker TJ, Gordon HL, Baker TM. Extended SMAS dissection as an approach to midface rejuvenation. *Clin Plast Surg*. 1995;22:295-311.
65. Owsley JQ, Roberts CL. Some anatomical observations on midface aging and long-term results of surgical treatment. *Plast Reconstr Surg*. 2008;121(1):258-268. doi:10.1097/01.prs.0000293872.14916.bb.
66. Nahai F. Sub-SMAS facelift with buccal fat transposition. In: Presented at IMCAS, Paris, 2012.
67. Barton FE, Ha R, Awada M. Fat extrusion and septal reset in patients with the tear trough triad: a critical appraisal. *Plast Reconstr Surg*. 2004;113(7):2115-2121.
68. Hamra ST. The role of the septal reset in creating a youthful eyelid-cheek complex in facial rejuvenation. *Plast Reconstr Surg*. 2004;113(7):2124-2141.
69. Millard DR Jr, Mullin WR, Hunsaker RH. Evaluation of a technique to correct nasolabial folds. *Plast Reconstr Surg*. 1992;89(2):356-365.
70. Majno G, Gabbiani G, Hirschel BJ, Ryan GB, Statkov PR. Contraction of granulation tissue in vitro: similarity to smooth muscle. *Science*. 1971;173(3996):548-550.
71. Mulliken JB, Glowacki J. Hemangiomas and vascular malformations in infant and children: a classification based on endothelial characteristics. *Plast Reconstr Surg*. 1982;69(3):412-422.

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