Original Paper

Cells Tissues Organs

Cells Tissues Organs 2010;191:47–56
DOI: 10.1159/000226276

Accepted after revision: February 13, 2009
Published online: June 24, 2009

Histotopographic Study of the Fibroadipose Connective Cheek System

Veronica Macchi[a] Cesare Tiengo[b] Andrea Porzionato[a] Carla Stecco[a] Enrico Vigato[a, b] Anna Parenti[c] Bruno Azzena[b] Andreas Weiglein[d] Francesco Mazzoleni[b] Raffaele De Caro[a]

[a]Section of Anatomy, Department of Human Anatomy and Physiology, [b]Department of Medical and Surgical Specialities, Clinic of Plastic Surgery, and [c]Section of Pathologic Anatomy, Department of Medical Diagnostic Sciences and Special Therapies, University of Padua, Padua, Italy; [d]Institute of Anatomy, University of Graz, Graz, Austria

Key Words
Aging · Fibroadipose connective system · Microanatomy · Platysma · Ptosis · Rhytidectomy · Superficial musculoaponeurotic system

Abstract
The purpose of this study was to investigate the morphology of the superficial musculoaponeurotic system (SMAS). Eight embalmed cadavers were analyzed: one side of the face was macroscopically dissected; on the other side, full-thickness samples of the parotid, zygomatic, nasolabial fold and buccal regions were taken. In all specimens, a laminar connective tissue layer (SMAS) bounding two different fibroadipose connective layers was identified. The superficial fibroadipose layer presented vertically oriented fibrous septa, connecting the dermis with the superficial aspect of the SMAS. In the deep fibroadipose connective layer, the fibrous septa were obliquely oriented, connecting the deep aspect of the SMAS to the parotid-masseteric fascia. This basic arrangement shows progressive thinning of the SMAS from the preauricular district to the nasolabial fold ($p < 0.05$). In the parotid region, the mean thicknesses of the superficial and deep fibroadipose connective tissues were 1.63 and 0.8 mm, respectively, whereas in the region of the nasolabial fold the superficial layer is not recognizable and the mean thickness of the deep fibroadipose connective layer was 2.9 mm. The connective subcutaneous tissue of the face forms a three-dimensional network connecting the SMAS to the dermis and deep muscles. These connective laminae connect adipose lobules of various sizes within the superficial and deep fibroadipose tissues, creating a three-dimensional network which modulates transmission of muscle contractions to the skin. Changes in the quantitative and qualitative characteristics of the fibroadipose connective system, reducing its viscoelastic properties, may contribute to ptosis of facial soft tissues during aging.

Abbreviations used in this paper

SMAS	superficial musculoaponeurotic system

V.M. and C.T. contributed equally to this study.

KARGER

Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

1422–6405/10/1911–0047$26.00/0

Accessible online at:
www.karger.com/cto

Prof. Raffaele De Caro
Section of Anatomy, Department of Human Anatomy and Physiology
University of Padua, Via A. Gabelli 65
IT–35127 Padua (Italy)
Tel. +39 049 827 2327, Fax +39 049 827 2328, E-Mail rdecaro@unipd.it

Introduction

From the original description of the superficial musculoaponeurotic system (SMAS) of the face in the 1970s [Mitz and Peyronie, 1976], its surgical dissection, mobilization and traction has become an ordinary technique in esthetic facial surgery. The term SMAS has generally been accepted in anatomy and clinical practice. In Gray's Anatomy [Standring et al., 2005], it is described as a single tissue plane in the face, composed of muscle fibers in some areas, and elsewhere of fibrous or fibroaponeurotic tissue, not directly attached to bone. A variety of SMAS dissection, with traction or plication, has become popular, as well as the evolution from the classic preauricular skin incision to the reduction of skin scars by means of endoscopic techniques. Most plastic surgeons contend that the creation of two distinct flaps, using one sub-SMAS and one subcutaneous plane, results in bidirectional rhytidectomy, improving the long-term surgical outcome and prolonging its esthetic results [Rees and Aston, 1977; Owsley, 1983]. Many authors [Furnas, 1989; Stuzin et al., 1992; Mendelson, 2001] have also demonstrated the importance of the so-called 'retaining ligaments', a series of ligaments connecting the SMAS to the underlying deep fascia in a discontinuous manner. Between these ligaments there are larger areas of non-adherence (glide planes), which allow facial mobility [Mendelson et al., 2002; Gassner et al., 2008]. During aging, this ligamentous system and all subcutaneous fibrous septa become attenuated, leading to many of the signs of the aging face, such as the development of jowls and prominent nasolabial folds [Stuzin et al., 1992].

In the last decade, macro- and microscopic studies have proved the real existence of the SMAS and its structure, and have identified its functional role [Pensler et al., 1985; Thaller et al., 1990; Har-Shai et al., 1997; Gardetto et al., 2002; Ghassemi et al., 2003; Huggins et al., 2007]. Whole-mount histological sections have been used only in a few studies, providing both histological details and tissue orientation [Barton, 1992; Gosain et al., 1993].

There are two prevailing opinions in the literature about the SMAS. The initial description [Mitz and Peyronie, 1976] of the SMAS proposed a topographical division into two portions: a thicker pretragal one over the parotid region and a thinner one in the anterior cheek region. In contrast, Jost and Levet [1984] supposed that the SMAS was formed of the external layer (sheet) of the parotid capsule and that it was therefore impossible to separate it from the parotid fascia. Some authors still do not believe either that the SMAS exists as an autonomous anatomical entity or that it can be detected in any facial region other than the parotid region [McKinney and Gottlieb, 1985; Gardetto et al., 2002].

These different opinions are a consequence of the lack of a systematic anatomic study of the fascia of the face in terms of structure, topography, extension, boundaries and connections with facial muscles and skin. The aim of this study was to investigate the macro- and microscopic morphology of the subcutaneous tissue of the face through anatomic dissection and histotopographic evaluation in order to clarify the functional role of the fibroadipose connective cheek system.

Materials and Methods

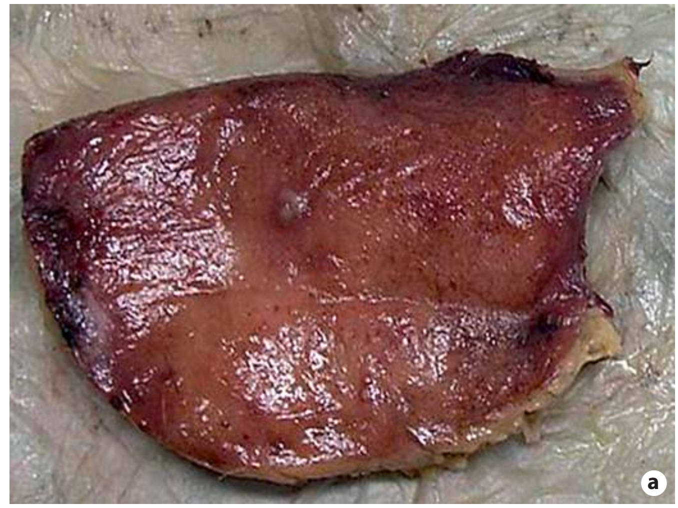
Macroscopic Dissection

During a practical course of surgical facial rejuvenation organized by the Clinic of Plastic Surgery and the Department of Human Anatomy of the University of Padua, held in Padua for theoretical and surgical demonstrations, and at the Institute of Anatomy of the University of Graz for direct anatomical exercises by trainers (all plastic surgeons), the architecture of the facial soft tissues of 8 cadavers, aged between 60 and 92 years, fixed by Thiel's method [Thiel, 1992], was macro- and microscopically analyzed. One side of the face was macroscopically dissected following classic subcutaneous and sub-SMAS rhytidectomy [Rees and Aston, 1977]. The incision lines of the skin were performed following the hairline, extending downwards to the ear anteriorly to the tragus, then curving round the inferior margin of the earlobe and prolonged vertically towards the sternocleidomastoid muscle. The skin and subcutaneous tissue were erased with sharp dissection forward to the nasolabial folds. The SMAS was then exposed, incised in the pretragal region and carefully elevated as a medially based flap. All peripheral nerve branches were identified and dissected.

On the other side of the face, a full-thickness specimen of soft cheek tissue was taken from the cutaneous to the mucosal aspect, confined by the following skin incision lines: (1) along the preauricular region; (2) zygomatic arch; (3) medially to the nasolabial fold, and (4) the buccal region along the inferior margin of the mandible (fig. 1). The nearly rectangular specimens were accurately oriented, and the four margins were marked with colored nylon thread, mounted on cardboard to avoid deformation artifacts and fixed by immersion in 10% formalin solution.

Histology and Immunohistochemistry

At the Laboratory of Clinical Anatomy of Padua, four samples were taken from the margins corresponding to: (1) parotid; (2) zygomatic; (3) nasolabial fold and buccal, and (4) cheek regions. During paraffin embedding, samples were oriented, with care being taken to obtain full-thickness sections from the skin to the deep layers. The 10-μm-thick sections were then stained with hematoxylin-eosin, Azan-Mallory and Weigert's stain for elastic fibers. Full-thickness sections were also processed for immunohistochemical study, carried out with polyclonal antibodies raised against S100 (Dako, Milan, Italy) for nervous tissues according to a previously described protocol [Scapinelli et al., 2006]. Morphometric evaluation was carried out with the help of image analysis software (Qwin Leica Imaging System, Cambridge, UK). For each region of the subcutaneous tissue, the following parameters were recorded: mean thickness of the subcutaneous tissue, superficial and deep fibroadipose connective tissue, superficial fascia and septa. The mean area and circularity factor of adipose lobules in the superficial and deep fibroadipose connective tissue were also recorded [Macchi et al., 2007]. Each region was subdivided into five equal parts and the thickness measured in each part. In order to reveal differences in thickness in the various regions, statistical analyses were performed with the Mann-Whitney, Kruskal-Wallis and Dunn's multiple comparison tests. $p < 0.05$ was considered to be statistically significant. Statistical calculations were carried out by Prism 3.0.3 (GraphPad Software, San Diego, Calif., USA).



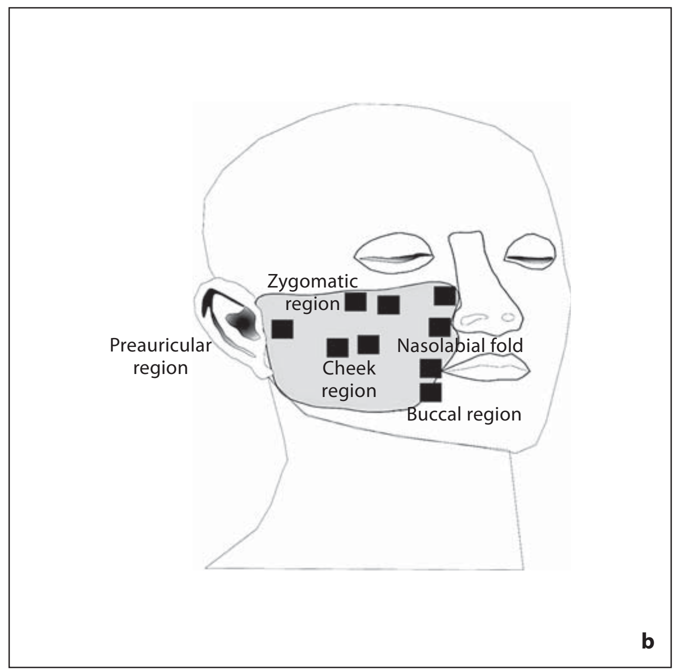


Fig. 1. Macroscopic appearance of a full-thickness specimen of the right side, from the cutaneous to the mucosal aspect (**a**), oriented according to the schematic drawing (**b**) showing the site of sampling of a full-thickness specimen and locations of cross-sections for microscopic analysis.

Results

Macroscopic Dissection

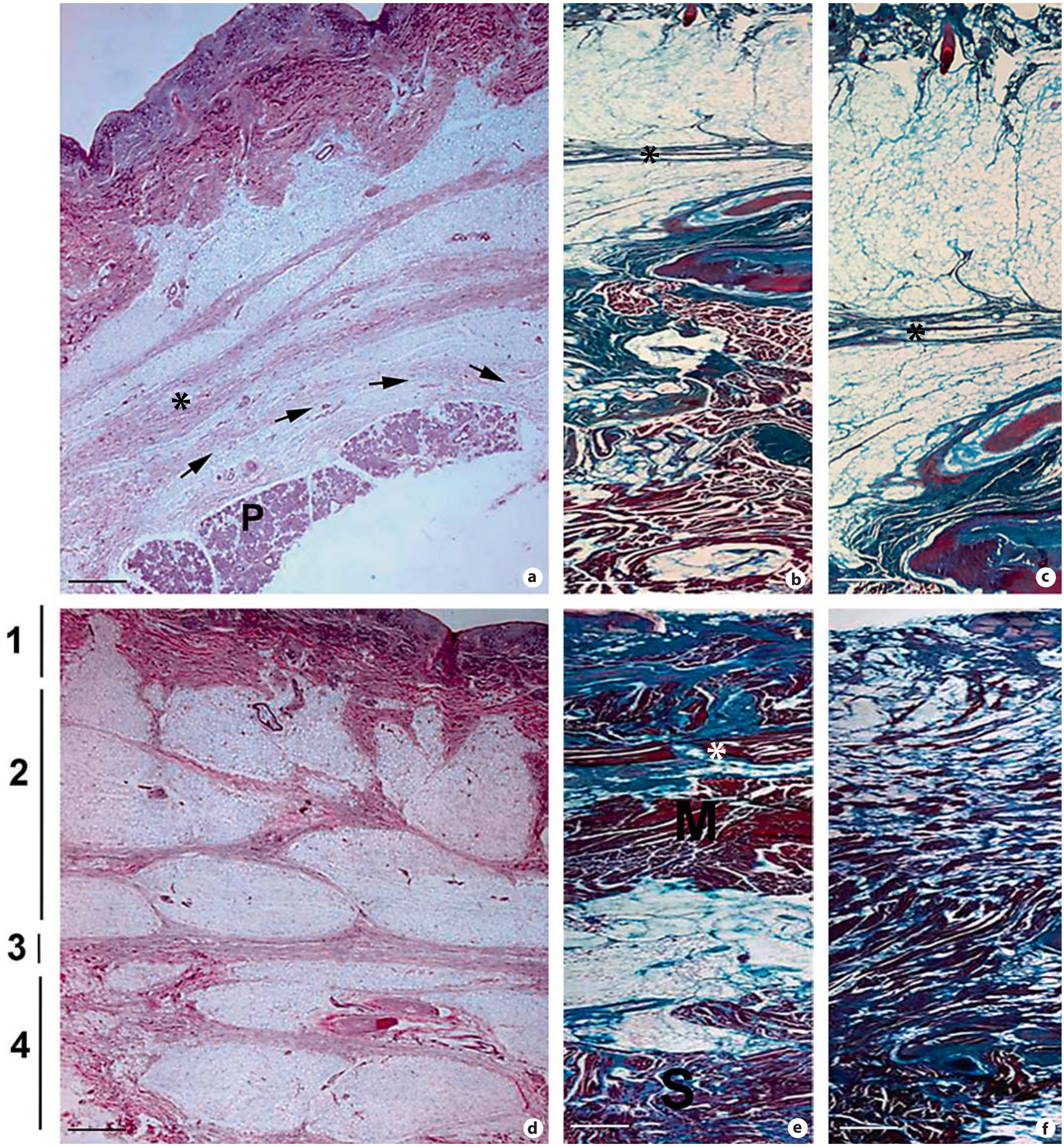
During macroscopic dissection, with a pretragal vertical incision the SMAS was always identified and easily erased from the parotid region. It was separated from the parotid fascia through a blunt dissection, elevated in continuity with the platysma muscle. No direct bone insertion was identified; the thickness of the SMAS decreased anteriorly to the parotid gland, towards the midline of the face. The zygomatic, buccal, temporal and marginal mandibular branches of the facial nerve anterior to the border of the parotid gland were identified and carefully preserved. A clear fibro-fatty layer was difficult to identify at the level of the zygomatic arch and nasolabial fold.

Histotopographic Study

In all full-thickness specimens, stratigraphic organization of the subcutaneous tissue was identified, from superficial to deep planes in the following layers: epidermis, corium, superficial fibroadipose connective layer with retinaculum cutis superficialis, laminar layer of connective tissue (superficial fascia or SMAS), deep fibroadipose connective layer with retinaculum cutis profundum and deep (muscular) fascia. This organization shows various regional characteristics.

Cheek Region

The mean thickness of the subcutaneous tissue was 5.45 ± 0.1 mm (fig. 2c). The superficial fibroadipose connective layer (mean thickness 1.64 ± 1.2 mm) presented fibrous septa (fig. 3b), vertically oriented (retinaculum cutis superficialis), with a few horizontal septa connecting the dermis with the superficial aspect of the SMAS. These vertical fibrous septa had a mean thickness of 210.4 ± 99 μm, and the horizontal fibrous septa 161.3 ± 63 μm. They were composed of collagen and abundant elastic fibers, and defined polygonal lobules of fat cells (circularity factor: mean 0.75 ± 0.13). The SMAS had a mean thickness of 423 ± 122 μm and was formed of multiple



*
P
a
*
b
*
c
1
2
3
4
d
*
M
S
e
f
2

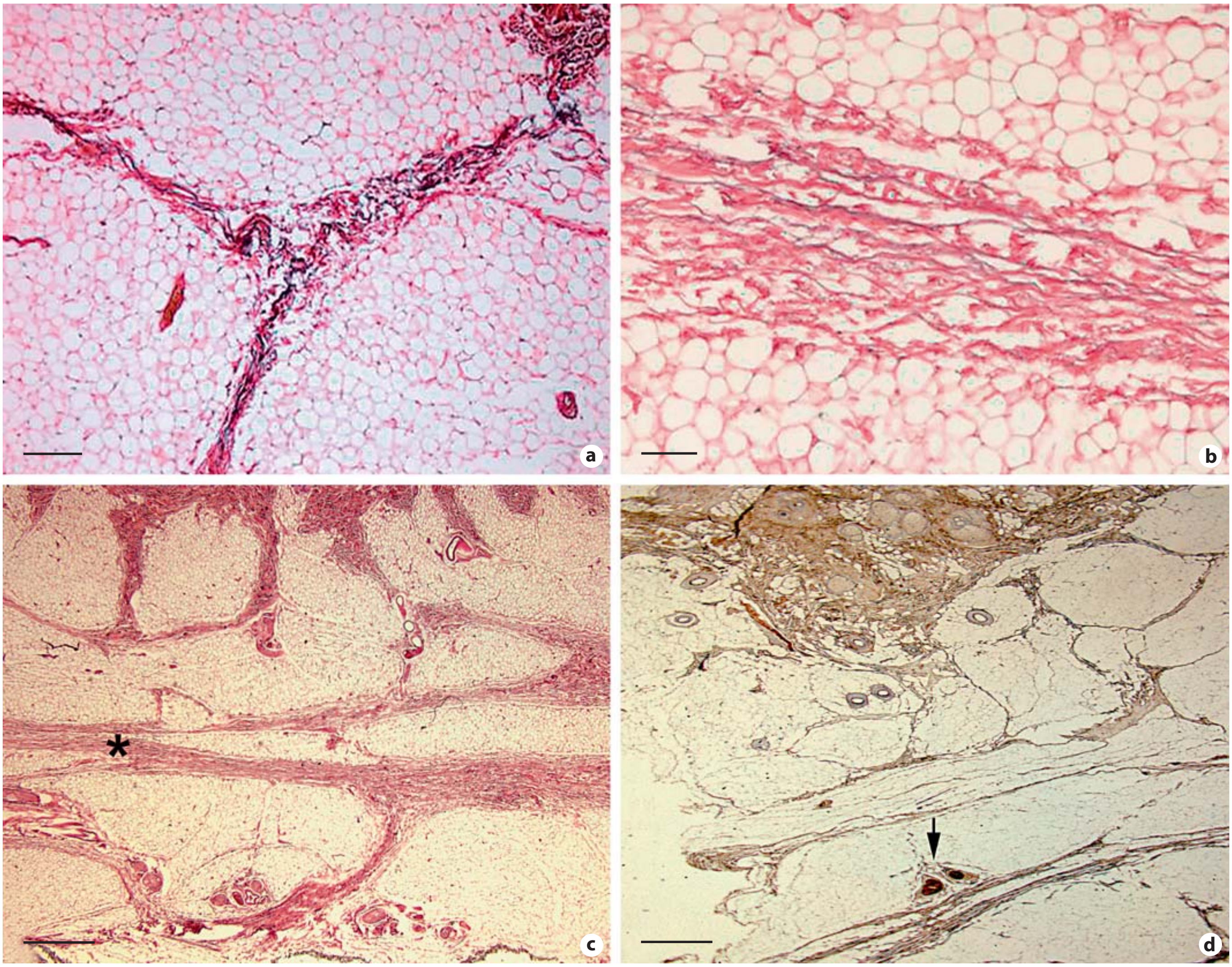


Fig. 3. Microscopic appearance of SMAS (**a**, scale bar = 100 μm), corresponding to multiple fibroelastic layers, and septa (**b**, scale bar = 25 μm). Weigert van Gieson. **c** Transverse section of the cheek region, showing conspicuous nerve bundles in the deep fibroadipose connective layer and small nerve fibers in the superficial fibroadipose connective layer; * = SMAS. HE. Scale bar = 500 μm. **d** Histological section stained with S100 in the nasolabial fold, showing nerve bundles in the deep fibroadipose connective layer. Scale bar = 500 μm.

Fig. 2. a Transverse section through the parotid region, showing SMAS, composed of multiple layers of fibroelastic tissue (*), close to the parotid fascia (arrows) and parotid capsula. The superficial fibroadipose connective layer is well represented; the deep layer is very thin. P = Parotid, azan-Mallory. **b**, **c** Transverse sections through the temporal region, showing the superficial temporal fascia (*), located between the well-represented superficial fibroadipose connective layer and the thin deep fibroadipose connective layer. Note scarce, thin fibrous septa. Azan-Mallory. **d** Transverse section through the cheek region, showing layered organization of subcutaneous tissue: 1 = skin; 2 = superficial fibroadipose connective layer; 3 = SMAS; 4 = deep fibroadipose connective layer. Note appearance of adipose lobules, polygonal in shape in the superficial layer and fusiform in the deep layer. Azan-Mallory. **e** Transverse section through the nasolabial fold, showing mimic muscles (M) closely located below the skin with little representation of the superficial fibroadipose connective layer (*). The deep fibroadipose connective layer is located between mimic and somatic muscles (S). Azan-Mallory. **f** Transverse section through the buccal region, showing close connection between the orbicularis oris muscle and the skin. Azan-Mallory. Scale bars = 1,000 μm.

fibroelastic layers, separated by loose connective tissue (fig. 3a). These laminae were of variable size, showed an undulating course, and were closely packed parallel to each other. Numerous elastic fibers were also evidenced by van Gieson stain. In the deep fibroadipose connective layer (mean thickness 2.84 ± 0.9 mm), the fibrous septa, rich in elastic fibers, were mainly horizontally and obliquely oriented (retinaculum cutis profundum), connecting the deep aspect of the SMAS to the deep (muscular) fascia of the masseter muscles. The horizontal septa had a mean thickness of 269.2 ± 156 μm and were significantly greater than those of the superficial fibroadipose connective layer ($p < 0.05$). The vertical septa had a mean thickness of 164.51 ± 75 μm; no significant statistical difference was found between the thickness of the vertical septa in the superficial and deep fibroadipose connective layer. They enveloped large fusiform lobules of fat cells (mean circularity factor: 0.5 ± 0.12). Many vascular structures were observed. The circularity factor of the superficial fibroadipose connective tissue was significantly greater than that of the deep fibroadipose connective layer ($p < 0.05$). Histological sections stained with S100 showed that conspicuous nervous bundles (mean diameter 279.7 ± 73.6 μm) were recognizable at the level of the deep fibroadipose connective layer, whereas small nerve fibers (mean diameter 104.2 ± 22.4 μm) were rarely observed within the superficial fibroadipose connective layer and free nerve endings at the boundary with the corium. The SMAS did not show evident nerve fibers.

Nasolabial Fold and Buccal Regions

The above subcutaneous architecture progressively changed in the nasolabial and buccal regions (fig. 2d, e). The superficial fibroadipose connective layer could be considered virtually absent, with rare adipose lobules. The SMAS mingles and envelops the mimic muscles (orbicolaris, levator labii superioris, depressor labii inferioris, levator and depressor anguli oris, and zygomaticus muscles) and had a mean thickness of 815 ± 78 μm, significantly greater than that of the cheek ($p < 0.05$), parotid ($p < 0.01$) and temporal regions ($p < 0.05$). The deep fibroadipose connective layer was well represented, with a mean thickness of 2.9 ± 0.5 mm with horizontally oriented fibrous septa, rich in elastic fibers, connecting the SMAS to the deep (muscular) fascia of the buccinator muscles. The horizontal septa had a mean thickness of 74.8 ± 30 μm and enveloped large fusiform lobules of fat cells (circularity factor: mean 0.61 ± 0.02). The vertical septa had a mean thickness of 177.13 ± 65 μm. Histological sections stained with S100 demonstrated that nervous bundles (mean diameter 169.5 ± 23.1 μm) were recognizable in the deep fibroadipose connective layer and within muscles. Free nervous endings were observed at the boundary with the corium.

Parotid Region

Here, subcutaneous tissue was less thick (2.93 ± 1.3 mm), with a great reduction in the deep fibroadipose connective layer (fig. 2b). The superficial fibroadipose connective layer had a mean thickness of 1.63 ± 0.2 mm with vertically oriented fibrous septa, connecting the dermis with the superficial aspect of the SMAS. The vertical fibrous septa were on average 254.32 ± 38 μm thick and the horizontal ones 172.24 ± 36 μm, defining polygonal lobules of fat cells (circularity factor: mean 0.53 ± 0.11). The SMAS was composed of multiple layers of fibroelastic tissue with loose connective components, rich in elastic fibers, with rare muscular fibers distributed along it. Its mean thickness was 386.4 ± 113 μm. The deep fibroadipose connective layer was very thin (mean 803.9 ± 650 μm) and closely packed between the SMAS and the parotid fascia. It was significantly thinner than the cheek, nasolabial fold and temporal regions ($p < 0.05$). The parotid fascia was formed of multiple layers of collagen fibers, with a few elastic fibers (408.7 ± 96 μm). The parotid capsula was composed of a single layer of connective tissue, from which intraparotid septa (334.02 ± 36 μm) originated. Histological sections stained with S100 demonstrated that nervous bundles occurred in the parotid fascia (mean diameter 171.2 ± 22.4 μm) and the superficial fibroadipose connective layer (mean diameter 116.2 ± 22.4 μm).

Temporal Region

In 3 cases, the temporal region was also available. The subcutaneous tissue was 6.80 ± 0.6 mm thick, and the deep fibroadipose connective layer (2.32 ± 1.1 mm) was much thinner (fig. 2a). The superficial fibroadipose connective layer was on average 3.65 ± 0.6 mm thick, significantly different from that of the cheek and parotid region ($p < 0.001$). It showed thin, vertically oriented, fibrous septa (mean thickness 159.95 ± 53.5 μm), connecting the dermis with the superficial aspect of the superficial temporal fascia. The horizontal septa were very thin (mean 66.35 ± 16.58 μm). The superficial temporal fascia (mean thickness of 337 ± 99 μm) was composed of multiple thick fibroelastic layers, with loose connective tissue, rich in elastic components, with rare muscular fibers, distributed along it. The deep fibroadipose connec-

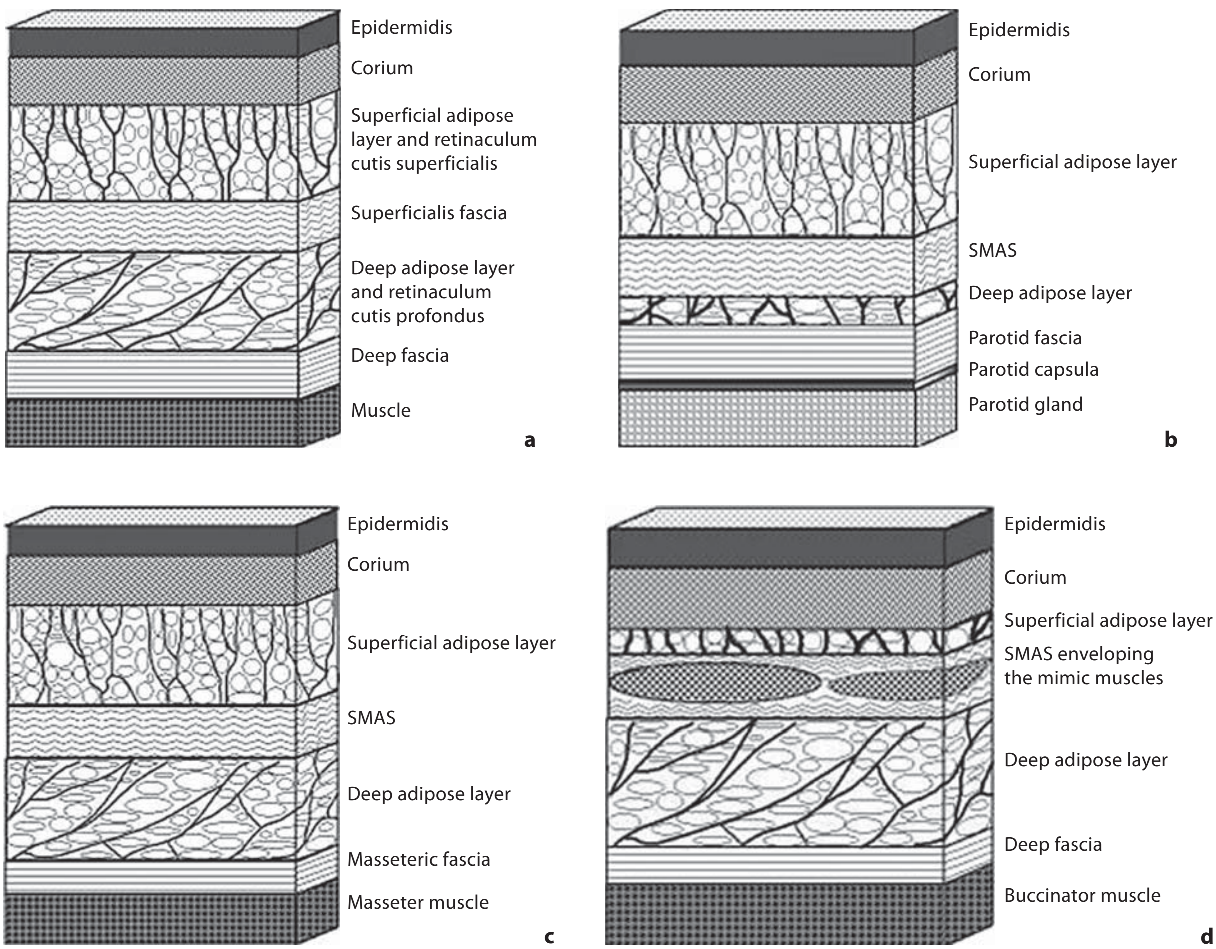


Fig. 4. Schematic drawing showing the basic pattern of organization of subcutaneous tissue (**a**) and its changes in the parotid region (**b**), the cheek region (**c**) and the nasolabial fold (**d**).

tive layer was thin (2.83 ± 0.8 mm), with oblique fibrous septa connecting the superficial to the deep temporal fascia. These septa were on average 126.97 ± 70 μm thick.

Discussion

While in the rest of the body subcutaneous tissue and the fascia superficialis are separated from the muscular compartment and adapt only slightly to its contractions, in the face a refined subcutaneous mechanism of connection between mimic muscles and skin exists [Lockwood, 1991]. Our clinical and histological results confirm that the layered architecture of the subcutaneous tissue of the face, from superficial to deep layers, corresponds to the epidermis, corium, superficial fibroadipose connective layer, a laminar layer of connective tissue (the so-called SMAS), deep fibroadipose connective layer and deep (muscular) fascia, consisting of multiple layers of tissues connecting the dermis with the facial muscles (fig. 4). This basic arrangement shows progressive regional thinning of the SMAS, from the preauricular region to the nasolabial fold ($p < 0.05$), together with regional variations in superficial and deep fibroadipose connective tissues. Indeed, in the parotid region, the SMAS is closely linked to the parotid fascia, and it is difficult to separate them, whereas in the nasolabial fold and buccal regions the SMAS continues and envelops the orbicolaris and zygomatic muscles. To the best of our knowledge, this is the first study demonstrating that the SMAS is a continuous layer from the parotid region to the nasolabial fold.

From the functional point of view, the facial muscles may be subdivided into somatic and mimic groups. The buccinator and masseter muscles are somatic, located in a deep plane below the muscular (deep) fascia. Both muscles show osseous cranial and caudal attachments: the masseter muscle arises from the zygomatic bone and the zygomatic arch, and is inserted on the mandibular ramus; the buccinator muscle arises from the maxilla and is inserted on the mandibula; posteriorly, its fibers are attached to the pterygomandibular raphe [Standring et al., 2005]. Thus, the medial border of the buccinator muscle and the medial and lateral borders of the masseter muscle show soft tissue attachments and lie close to the submucosa of the cheek. The orbicolaris, levator labii superioris, depressor labii inferioris, levator and depressor anguli oris and zygomaticus muscles are mimic muscles, in continuity with the SMAS, very close to the corium-epidermis. The orbicolaris muscle is subdivided into the *pars peripheralis,* which receives contributions from the buccinator, levator and depressor anguli oris and zygomaticus muscles, and the *pars marginalis,* which shows lateral attachments to the modiolus. The other mimic muscles show osseous cranial or caudal attachments, from the maxilla and zygomatic bone and from the mandible, respectively, whereas medially and laterally they only have soft tissue attachments [Standring et al., 2005]. Thus, both groups show osseous cranial-caudal attachments, but lie between the dermis and the mucosae medially and laterally.

Our results show that the thickness of the superficial and deep fibroadipose connective tissues varies in the different regions, with mean thicknesses of 1.63 and 0.8 mm, respectively, in the parotid region, whereas the superficial layer is not recognizable in the region of the nasolabial fold, and the mean thickness of the deep fibroadipose connective layer is 2.9 mm. The fibroadipose connective tissue of the face shows morphofunctional organization according to the type of adjacent muscle; its superficial layer is virtually absent in the nasolabial fold, and the skin is closely connected to the mimic muscles, whereas the deep layer is almost completely missing and the SMAS adheres to the parotid fascia in the parotid region. Thus, it may be hypothesized that the amount of superficial fibroadipose connective tissue is related to the mimic muscles, whereas the morphology of the deep fibroadipose connective tissue is affected by somatic muscles.

The morphology of the adipose lobules in the superficial and deep fibroadipose connective tissues is remarkable: the lobules in the former tissue are areolar in shape (mean circularity factor: 0.75) and represent a plastic system, which can adapt the skin to the activity of the mimic muscles. The fusiform lobules (mean circularity factor: 0.50; $p < 0.05$) in the deep fibroadipose connective tissue may represent a sliding system for deep somatic muscle contraction. In the parotid region, where the somatic (deep) muscles are absent, the deep fibroadipose connective tissue is poorly represented (mean thickness 0.8 mm). In the other regions (cheek and nasolabial fold), where the masseter and buccinator muscles are located, a sliding plane is useful, and the deep fibroadipose connective tissue is well represented (mean thickness 2.9 mm). A further sliding plane may be represented by the buccal fat pad, composed of a variable, but usually considerable, amount of adipose tissue, often encapsulated and forming a biconcave mass, which occupies the interval between the buccinator and masseter muscles [Bichat, 1803] and which is overlain by the parotid-masseteric fascia [Standring et al., 2005].

Standring et al. [2005] described the superficial temporal fascia as a fascial layer which lies in the same plane as the SMAS but not in continuity with it, whereas Ferreira et al. [2006] considered the superficial temporal fascia, SMAS and platysma as superficial fascia with different denominations, depending on the region considered. In our study, layered architecture is recognizable in the temporal region, as the superficial temporal fascia is located between the superficial and deep fibroadipose connective tissue; the vertical and horizontal septa are not appreciable. Thus, the SMAS may be considered as the facial continuation of the superficial temporal fascia.

Face-lifting which requires resuspension of the SMAS anterior to the parotid gland is accompanied by the risk of facial nerve injury, because the branches of the facial nerve that emerge from the anterior edge of the parotid gland are exposed when the SMAS is elevated [Wilhelmi et al., 2003]. During our dissections, numerous nerve branches were found running on the superficial surface of the masseter muscle, and microscopy and immunohistochemistry revealed conspicuous nerve bundles in the deep fibroadipose connective tissue, whereas small nerve fibers and free nerve endings were found in the superficial tissue, close to the corium.

In most areas of the face, a distinct plane can be surgically erased deeply to the SMAS. It is continuous with the plane between the platysma muscle and the superficial layer of the deep cervical fascia. However, Mitz and Peyronie [1976] reported that, at the level of the parotid gland, the SMAS appears firmly blended with the superficial aspect of the parotid fascia, so that a clear sub-SMAS plane is difficult to define. Although the deep fibroadipose connective tissue is very thin, our histological observations identified a separation between the parotid fascia and the SMAS, due to their different characteristics. In the parotid fascia, the collagen component prevails, whereas the overlying SMAS is rich in elastic fibers and adipose cells. Thus, in this region, there are three different layers above the parotid gland: (1) capsula propria (mean thickness 170 μm), from which interlobular septa penetrate into the gland; (2) parotid fascia (mean thickness 408 μm), and (3) SMAS, separated by loose cellular tissue (mean thickness 386 μm) [Thaller et al., 1990; Stuzin et al., 1992; Gosain et al., 1993; Ramsaroop et al., 2006].

These observations support the hypothesis that the SMAS is an evolutionary platysma muscle [Thaller et al., 1990] and that, during the mesenchymal development of the soft tissue of the face, the SMAS becomes a fibrous structure, representing a central tendon for the perimetric muscles. In fact, our findings show that the SMAS is a continuous layer extending from the preauricular region to the nasolabial fold, presenting a peculiar appearance in the different regions. In the cheek, it appears as a multilaminar layer of connective tissue, very close to the parotid fascia in the parotid region, and continues in the mimic muscles of the zygomatic region and nasolabial fold. Thus, it may represent a 'central tendon' for coordinated contraction of the mimic musculature of the face, being a *mimic-connecting connective plate* (fig. 5).

Our morphologic evaluations on subcutaneous tissue show two different organizations of subcutaneous fibroadipose lobules: those of the superficial fibroadipose connective tissue form a dense polygonal structure, and those of the deep tissue have a fusiform appearance. These two shapes may impart different viscoelastic properties to the superficial and deep layers, being able to adapt their size to dynamic variations. This may fit the morphofunctional role of fibroadipose tissue in other regions. The orbital areolar connective tissue is an important suspensor mechanism of the eye, cooperating closely with the other orbital structures and forming a functional anatomic entity [Koornneef, 1979]. Retroperitoneal pelvic connective tissue may act as a shock absorber, particularly efficient in response to sudden increases in abdominal pressure

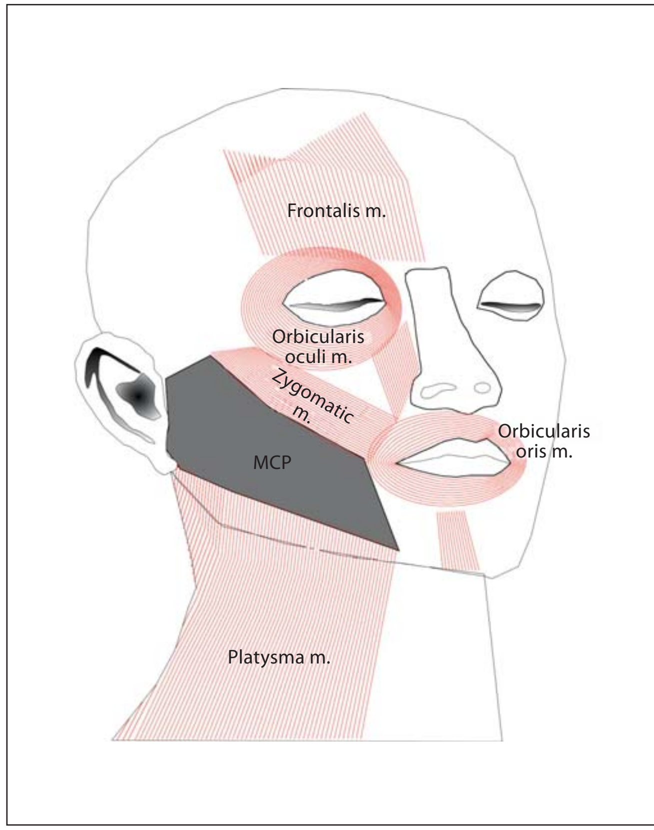


Fig. 5. Schematic drawing showing the location of the mimic connecting plate (MCP) and adjacent muscles.

[De Caro et al., 1998]. The arrangement of the fibroadipose tissue sheaths of the epineurium of the musculocutaneous nerve may be compared to a 'telescope', which allows harmonic compliance between variations in the length of the coracobrachialis muscle with respect to the constant course of the musculocutaneous nerve [Macchi et al., 2007]. The deep fibroadipose connective layer of the SMAS may represent a buffer device with respect to deep muscle activity, since it can modulate excessive involvement of facial physiognomy due to the direct transmission of collateral contraction effects during the activity of the masseter and buccinator muscles (masticatory and phoniatric functions) to the overlying cutaneous facial plane. In addition, the layered architecture of the SMAS may be able to modulate harmonic movements to the skin through the vertical septa. The subcutaneous tissue of the face forms a three-dimensional network of connective laminae linking the SMAS to the dermis and deep muscles. These laminae connect adipose lobules of various sizes within the superficial and deep fibroadipose connective tissues, i.e. a 3-D network which transmits and modulates muscle contractions to the skin. Changes in the quantitative and qualitative characteristics (type of collagen and elastic fibers) of the fibroadipose connective system may explain the ptosis of soft facial tissues during aging due to loss of its viscoelastic properties.

The anatomy of the subcutaneous tissue of the face is of renewed interest, since new minimally invasive techniques have been established in cosmetic surgery. In fact, through small cheek skin incisions, suspension sutures, composed of hooks or cones, may be introduced by a trocar into the subcutaneous tissue from the temporal region to the cheek, and cranially pulled and anchored to the deep temporal fascia. The advantage of this technique is the possibility of pulling the cheek subdermis, elevating sagging skin, and restoring or enhancing a patient's facial appearance by means of vertical traction without any bloody dissection that cuts fibrous septa and ligaments and disarranges the sophisticated 3-D architecture of the subcutaneous tissue [Isse, 1997; Ramirez, 1998, 2001]. Our findings may be useful in validating the anatomic basis of these new mini-invasive techniques and their long-term clinical results, and in analyzing changes in the fibroadipose connective cheek system during the aging process.

Acknowledgments

The authors are grateful to Dr. G. Sarasin and A. Rambaldo for their technical assistance.

References

Barton, F.E., Jr (1992) The SMAS and the nasolabial fold. Plast Reconstr Surg *89:* 1054–1057.

Bichat, X. (1803) Traité d'anatomie descriptive, ed 2. Paris, Brasson, p 64.

De Caro, R., F. Aragona, A. Herms, D. Guidolin, E. Brizzi, F. Pagano (1998) Morphometric analysis of the fibroadipose tissue of the female pelvis. J Urol *160:* 707–713.

Ferreira, L.M., B. Hochman, R.F. Locali, L.M. Rosa-Oliveira (2006) A stratigraphic approach to the superficial musculoaponeurotic system and its anatomic correlation with the superficial fascia. Aesthetic Plast Surg *30:* 549–552.

Furnas, D.W. (1989) The retaining ligaments of the cheek. Plast Reconstr Surg *83:* 11–16.

Gardetto, A., J. Dabering, C. Rainer, J. Piegger, H. Piza-Katzer, H. Fritsch (2003) Does a superficial musculoaponeurotic system exist in the face and neck? An anatomical study by the tissue plastination technique. Plast Reconstr Surg *111:* 664–672.

Gassner, H.G., A. Rafii, A. Young, C. Murakami, K.S. Moe, W.E. Larrabee (2008) Surgical anatomy of the face. Arch Facial Plast Surg *10:* 9–19.

Ghassemi, A., A. Prescher, D. Riediger, A. Axer (2003) Anatomy of the SMAS revisited. Aesthetic Plast Surg *27:* 258–264.

Gosain, A.K., N.J. Yousif, G. Madiedo, D.L. Larson, H.S. Matloub, J.R. Sanger (1993) Surgical anatomy of the SMAS: a reinvestigation. Plast Reconstr Surg *92:* 1254–1263.

Har-Shai, Y., S.R. Bodner, D. Egozy-Golan, E.S. Lindenbaum, O. Ben-Izhak, V. Mitz, B. Hirshowitz (1997) Viscoelastic properties of the superficial musculoaponeurotic system (SMAS): a microscopic and mechanical study. Aesthetic Plast Surg *21:* 219–224.

Huggins, R.J., M.E. Freeman, J.B. Kerr, B.C. Mendelson (2007) Histologic and ultrastructural evaluation of sutures used for surgical fixation of the SMAS. Aesthetic Plast Surg *31:* 719–724.

Isse, N.G. (1997) Endoscopic facial rejuvenation. Clin Plast Surg *24:* 213–231.

Jost, G., Y. Levet (1984) Parotid fascia and face lifting: a critical evaluation of the SMAS concept. Plast Reconstr Surg *74:* 42–51.

Koornneef, L. (1979) Orbital septa: anatomy and function. Ophthalmology *86:* 876–880.

Lockwood, T.E. (1991) Superficial fascial system (SFS) of the trunk and extremities: a new concept. Plast Reconstr Surg *87:* 1009–1018.

Macchi, V., C. Tiengo, A. Porzionato, A. Parenti, C. Stecco, F. Bassetto, R. Scapinelli, G. Taglialavoro, R. De Caro (2007) Musculocutaneous nerve: histotopographic study and clinical implications. Clin Anat *20:* 400–406.

McKinney, P., J. Gottlieb (1985) The relationship of the great auricular nerve to the superficial musculoaponeurotic system. Ann Plast Surg *14:* 310–314.

Mendelson, B.C. (2001) Surgery of the superficial musculoaponeurotic system: principles of release, vectors, and fixation. Plast Reconstr Surg *107:* 1545–1552.

Mendelson, B.C., A.R. Muzaffar, W.P. Adams, Jr (2002) Surgical anatomy of the midcheek and malar mounds. Plast Reconstr Surg *110:* 885–896.

Mitz, V., M. Peyronie (1976) The superficial musculoaponeurotic system (SMAS) in the parotid and cheek area. Plast Reconstr Surg *58:* 80–88.

Owsley, J.Q., Jr (1983) SMAS-platysma facelift. A bidirectional cervico-facial rhytidectomy. Clin Plast Surg *10:* 429–440.

Pensler, J.M., J.W. Ward, S.W. Parry (1985) The superficial musculoaponeurotic system in the upper lip: an anatomical study in cadavers. Plast Reconstr Surg *75:* 488–494.

Ramirez, O.M. (1998) High-tech facelift. Aesthetic Plast Surg *22:* 318–328.

Ramirez, O.M. (2001) Full face rejuvenation in three dimensions: a 'face-lifting' for the new millennium. Aesthetic Plast Surg *25:* 152–164.

Ramsaroop, L., B. Singh, L. Allopi, J. Moodley, P. Partab, K.S. Satyapal (2006) The surgical anatomy of the parotid fascia. Surg Radiol Anat *28:* 33–37.

Rees, T.D., S.J. Aston (1977) A clinical evaluation of the results of submuscular-aponeurotic dissection and fixation in face lifts. Plast Reconstr Surg *60:* 851–859.

Scapinelli, R., C. Stecco, A. Pozzuoli, A. Porzionato, V. Macchi, R. De Caro (2006) The lumbar interspinous ligaments in humans: anatomical study and review of the literature. Cells Tissues Organs *183:* 1–11.

Standring, S., H. Ellis, J. Healy, D. Johnson, A. Williams (2005) Gray's Anatomy, ed 39. London, Churchill Livingstone, pp 456–458.

Stuzin, J.M., T.J. Backer, H.L. Gordon (1992) The relationship of the superficial and deep facial fascias: relevance to rhytidectomy and aging. Plast Reconstr Surg *89:* 441–449.

Thaller, S.R., S. Kim, H. Patterson, M. Wildman, A. Daniller (1990) The submuscular aponeurotic system (SMAS): a histologic and comparative anatomy evaluation. Plast Reconstr Surg *86:* 690–696.

Thiel, W. (1992) Die Konservierung ganzer Leichen in natürlichen Farben. Ann Anat *174:* 185–195.

Wilhelmi, B.J., A. Mowlavi, M.V. Neumeister (2003) The safe face lift with bony anatomic landmarks to elevate the SMAS. Plast Reconstr Surg *111:* 1723–1726.