Pertinent Anatomy and Analysis for Midface Volumizing Procedures

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Background: The study was conducted to construct an anatomically inspired midfacial analysis facilitating safe, accurate, and dynamic nonsurgical rejuvenation. Emphasis is placed on determining injection target areas and adverse event zones.
Methods: Twelve hemifacial fresh cadavers were dissected in a layered fashion. Dimensional measurements between the midfacial fat compartments, prezygomatic space, mimetic muscles, and neurovascular bundles were used to develop a topographic analysis for clinical injections.
Results: A longitudinal line from the base of the alar crease to the medial edge of the levator anguli oris muscle (1.9 cm), lateral edge of the levator anguli oris muscle (2.6 cm), and zygomaticus major muscle (4.6 cm) partitions the cheek into two aesthetic regions. A six-step facial analysis outlines three target zones and two adverse event zones and triangulates the point of maximum cheek projection. The lower adverse event zone yields an anatomical explanation to inadvertent jowling during anterior cheek injection. The upper adverse event zone localizes the palpebral branch of the infraorbital artery. The medial malar target area isolates quadrants for anterior cheek projection and tear trough effacement. The middle malar target area addresses lid-cheek blending and superficial compartment turgor. The lateral malar target area highlights lateral cheek projection and locates the prezygomatic space.
Conclusions: This stepwise analysis illustrates target areas and adverse event zones to achieve midfacial support, contour, and profile in the repose position and simultaneous molding of a natural shape during animation. This reproducible method can be used both procedurally and in record-keeping for midface volumizing procedures. (*Plast. Reconstr. Surg.* 135: 818e, 2015.)

As the human face ages, soft-tissue descent is seen and manifested in the form of deep folds and wrinkles, prominent jowling, and loss of malar projection. In recent decades, clinical scientists in our field have redefined how we perceive and understand midfacial anatomy. Evidence has emerged discussing the anatomical changes that occur in compartmentalized facial fat and facial retaining ligaments. As a result, a paradigm shift has occurred implicating descent and deflation of fat compartments along with ligamentous attenuation as components to facial aging. These findings have provoked both cadaveric and clinical studies exploring the cause, prevention, and treatment of these aesthetic changes.[1–28] To date, there is universal agreement that certain

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changes do exist; however, the spatial relationship of these compartments with surrounding structures in dynamic facial movement has not been fully established. A greater in-depth understanding of the fat compartment synergy with surrounding structures and topographic impact of facial fat in the aging patient is essential. Understanding these relationships will facilitate more precise treatment modalities, providing an effective and durable result for our patients, and facilitate record-keeping in volumizing procedures.

Clinically, we have seen three particular adverse events following midface injections. The first is superficial volumizing of the infraorbital "malar" fat compartment following percutaneous injection targeted at improving lateral cheek projection. This results in an iatrogenic malar mound (Figs. 1 and 2). The second is intraarterial needle injection following percutaneous injection targeted at tear-trough effacement. The last is significant jowling following percutaneous injections targeted at the deep medial cheek fat compartment for increased anterior cheek projection (Fig. 3). The objective of this study was to develop a three-dimensional understanding of anatomical relationships existing in the midface and to translate this understanding into a functional analysis for procedural planning and safety. We hope to examine the anatomical sequence that occurs between the fat compartment layers and potential spaces during facial animation, to better understand the relationship between the orbitomalar ligament, orbicularis oculi muscle, and the clinical malar mound. Based on our findings, we intend to outline target areas and adverse event zones to be used for dynamic nonsurgical and surgical (fat grafting) rejuvenation of the midface. With knowledge of the membranous property of the posterior surface of the orbicularis oculi, blunt cannulas should be able to penetrate the prezygomatic space laterally and inferiorly, gliding freely within the space.

MATERIALS AND METHODS

Twelve hemifacial fresh cadaver specimens were injected with methylene blue using the technique described previously by Rohrich et al.[1,8] The superficial and deep fat compartment layers were injected in an alternating fashion to delineate septal partitions of each compartment. Each specimen was dissected under loupe magnification in a layered fashion. The first layer consisted of a skin-only flap elevated medial to lateral from the alar base along the lateral border of the nasolabial fat compartment and superiorly along the cutaneous

Fig. 1. Photographic illustration of an iatrogenic malar mound resulting from superficial injection in the infraorbital "malar" fat compartment. Note the cutaneous insertions of the orbitomalar ligament superiorly and the zygomaticocutaneous ligaments inferiorly. (Printed with permission from Dr. Levent Efe.)

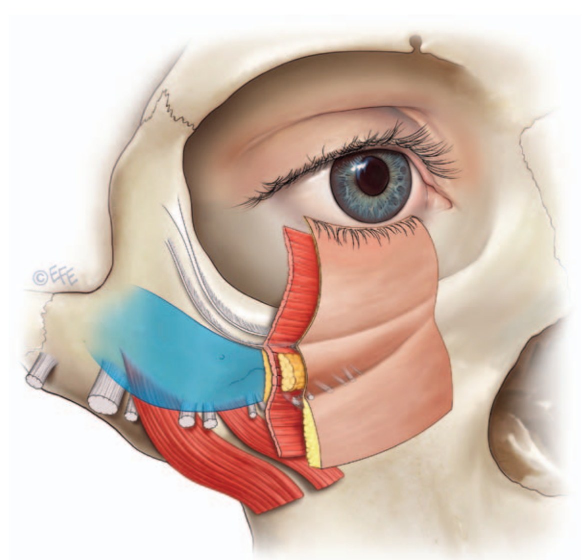


Fig. 2. Illustration of the anatomical depth relationships involved in iatrogenic malar mounds. The prezygomatic space is demonstrated in the deep suborbicularis plane (blue capsule). The orbitomalar ligament is demonstrated arborizing through the orbicularis oculi muscle inserting into the skin forming the tear-trough crease. The zygomaticocutaneous ligaments arborize through the orbicularis, forming a partition between the infraorbital "malar" fat compartment superiorly and superficial cheek compartment inferiorly. The cutaneous insertion of the ligaments forms the characteristic skin crease demonstrated in clinical malar mounds. (Printed with permission from Dr. Levent Efe.)

Fig. 3. Preprocedure and postprocedure photographic series of deep medial cheek fat compartment injection. (*Above*) Preprocedure photographs. (*Below*) Postprocedure photographs taken 2 weeks after attempted injection of the deep medial cheek fat compartment demonstrating jowling.

insertion of the zygomaticocutaneous ligaments (Fig. 1). The second layer consisted of the superficial midface fat compartments (nasolabial, medial superficial, middle superficial, and infraorbital "malar" compartments). A separate dissection on the same specimen raised a classic skin and muscle flap at the ciliary margin and exposed the arcus marginalis. The arcus marginalis was released and the space anterior to the preperiosteal fat was entered. A vertical incision was made in the skin-muscle flap at the level of the pupil. This was extended downward to the surface anatomy of the zygomaticocutaneous ligaments. Upward distraction of the two sides of the split lower eyelid exposed an areolar space posteriorly bounded by the dense capsule of the preperiosteal fat. Caudally, dense fibrous attachments are present composed of the zygomaticocutaneous ligaments and maxillary insertions of the orbicularis oculi. Laterally, this space arborizes with the lateral orbital thickening. After removal of the second layer, the remaining in situ layer consisted of the mimetic muscles and underlying deep midface fat compartments (i.e., medial sub–orbicularis oculi fat, lateral sub–orbicularis oculi fat, and deep medial cheek). On elevation of the orbicularis oculi and sub–orbicularis oculi fat, the preperiosteal fat was identified. The facial artery, zygomaticofacial vascular bundle, and infraorbital neurovascular bundle were identified (Figs. 4 and 5).

The locations of the zygomaticus major, levator anguli oris, and levator labii superioris muscles were measured from the alar crease (Table 1). Dimensions of the midface fat compartments were measured. Spatial relationships between the mimetic muscles and fat compartments were documented. The collected measurements and dissection observations were used to create a stepwise facial analysis (Figs. 4 and 6). (**See Video, Supplemental Digital Content 1,** which shows the

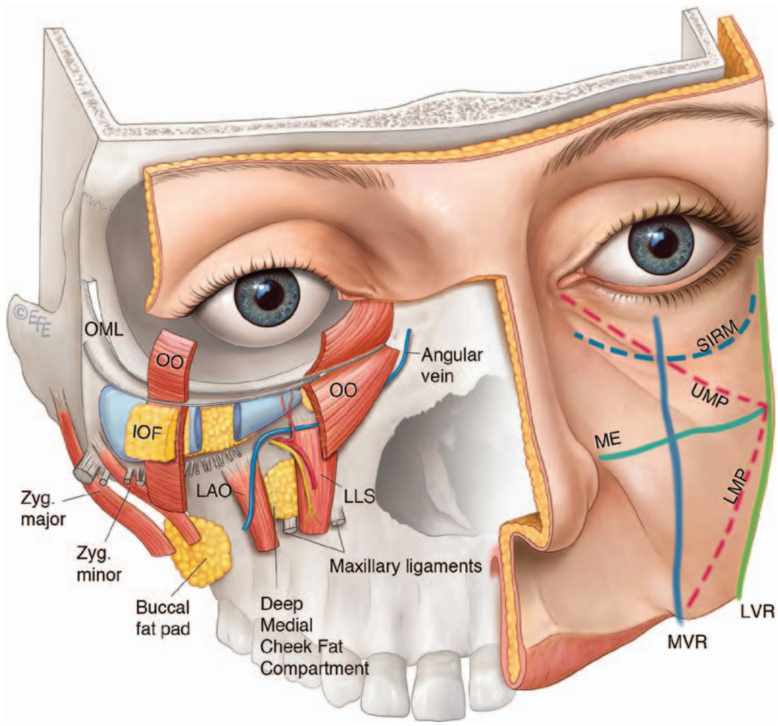


Fig. 4. Topographic markings for midface analysis are demonstrated on the left hemiface, including the malar equator (*ME*), medial vertical reference (*MVR*), lateral vertical reference (*LVR*), lower malar partition (*LMP*), upper malar partition (*UMP*), and infraorbital rim margin (*SIRM*). The right hemiface illustrates the deep fat compartment layers. The sub–orbicularis oculi fat is adherent to the undersurface of the orbicularis oculi. The prezygomatic space (blue capsule) overlies the preperiosteal fat. The orbitomalar ligament (*OML*) and zygomaticocutaneous (*Zyg*) ligaments are represented as the superior and inferior borders of the prezygomatic space. Injection caution areas including the palpebral branch of the infraorbital artery and buccal recess are illustrated. *OO*, orbicularis oculi; *IOF*, infraorbital fat; *LAO*, levator anguli oris; *LLS*, levator labii superioris. (Printed with permission from Dr. Levent Efe.)

conceptual description of the midfacial anatomical architecture, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B272***. **See Video, Supplemental Digital Content 2,** which is a demonstration of a topographic analysis for midface volumization procedures, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B273***.)

RESULTS

Part 1: Midfacial Anatomy

A separate grouping of anatomical relationships and fat compartment composition was observed above a longitudinal line drawn from the base of the alar crease. Therefore, we begin by partitioning the midcheek into upper and lower regions for anatomical analysis (Figs. 4 and 6).

In the lower malar region, the first structure of importance is the deep medial cheek fat compartment. The bulk of deep medial cheek fat lies between the alar crease and the medial edge of the levator anguli oris, a measured area of approximately 1.9 cm in width (Table 1). The compartment lies deep on the maxilla posterior to the levator labii superioris. As the deep medial cheek fat proceeds laterally (beneath the levator anguli oris) to the maxillary deflection, the fat becomes thin, loose and weakly septated (Figs. 4, 5, and 7). The tail of the compartment approaches an areolar cavern deep to the superficial fat compartment layer and lateral to the levator anguli oris. This loose areolar plane descends posteroinferiorly into the buccal fat pad. This space is triangulated by the zygomaticus major, levator anguli oris, and

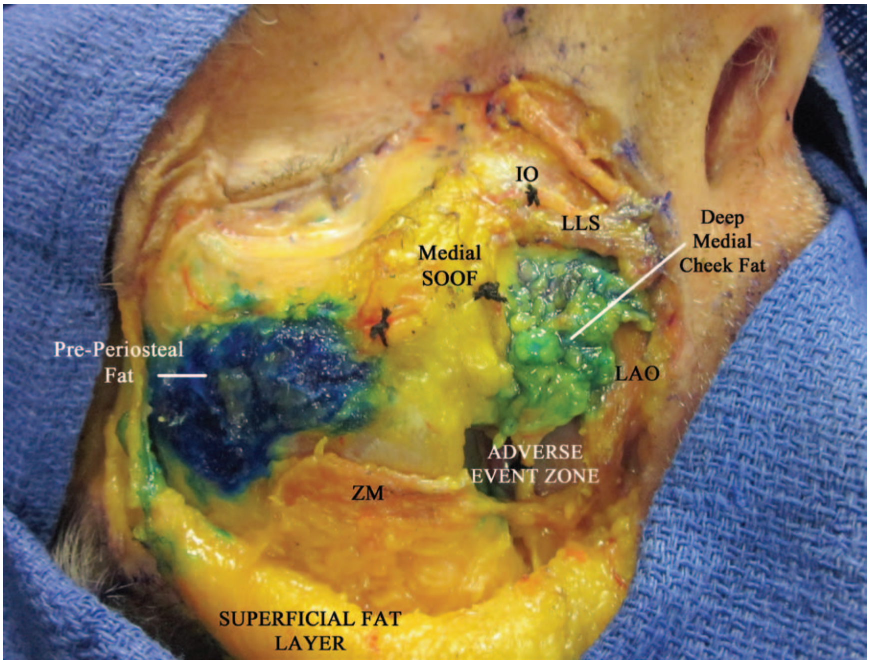


Fig. 5. Lateral view showing the superficial fat compartments retracted. The zygomaticus major (*ZM*) and levator labii superioris (*LLS*) are labeled. The orbicularis has been resected along the prezygomatic space capsule. The preperiosteal fat is stained with methylene blue, and remnants of lateral sub–orbicularis oculi fat (*SOOF*) are noted overlying on the capsule of the preperiosteal fat. Medial sub–orbicularis oculi fat and infraorbital (*IO*) neurovascular bundle are labeled. The loose areolar consistency of the deep medial cheek fat is noted lateral to the levator anguli oris (*LAO*). A cavernous communication into the buccal recess is noted, denoting a deep injection adverse event zone.

zygomaticomaxillary prominence (Figs. 4, 5, and 7). The lateral border of the space is consistent with the medial edge of the zygomaticus major (4.6 cm from the alar crease). The medial border of the space is the lateral edge of the levator anguli oris (2.6 cm from the alar crease) (Table 1).

The role of deep medial cheek fat in anterior cheek projection has been anatomically discussed in the literature.[8,25] The delineation of the interplay between the levator anguli oris and the deep medial cheek fat is important for anatomical isolation of the deep medial cheek fat (Fig. 4). Previous studies have described the levator anguli oris as the partition of medial and lateral portions of the deep medial cheek fat.[18] The dissections in this study find the compartment to be largest medial to the levator anguli oris (Figs. 4, 5, and 7). Therefore, the area between the alar crease and levator anguli oris (1.9 cm) is a desired location to inject within the deep medial cheek fat (Table 1 and Figs. 4 and 6). We and others have clinically observed inadvertent jowling by attempted volumizing of the deep medial cheek fat[29,32] (Fig. 1). We believe this to be the result of laterally displaced injections resulting in placement within the described areolar space lateral to the levator anguli oris. Detailed examination of this areolar zone reveals a direct cavern posterolaterally into the buccal fat. Gierloff et al. refer to a superficial extension of the buccal fat pad that likely traverses within this region.[18] In this cadaveric study, the consistency of the buccal extension fat compartment was found to be loose (nonfibrous) and poorly confined.

There is a distinct plane between the superficial and deep layers of facial fat in the upper malar region (Figs. 4 and 8 through 12). In this region lies the prezygomatic space. Previously described by Mendelson et al., this potential space is bordered superolaterally by the lateral orbital thickening within the temporomalar partition (Fig. 11).

Table 1. Longitudinal Measurements from the Base of the Alar Crease to Edges of Select Mimetic Muscles

Anatomical Landmark	Distance from Alar Crease (cm)
Levator anguli oris (medial edge)	1.9
Levator anguli oris (lateral edge)	2.6
Zygomaticus major (medial edge)	4.6

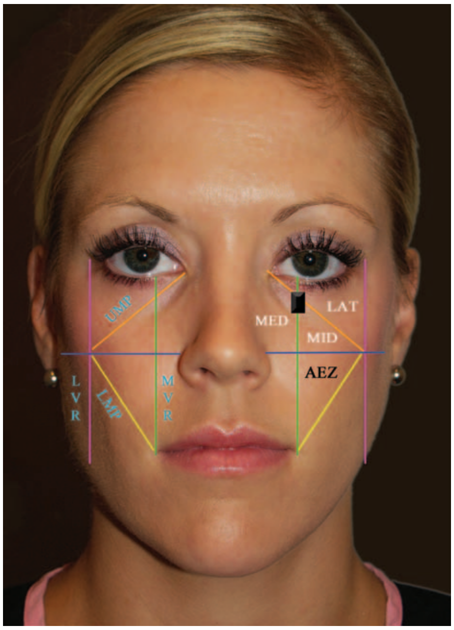
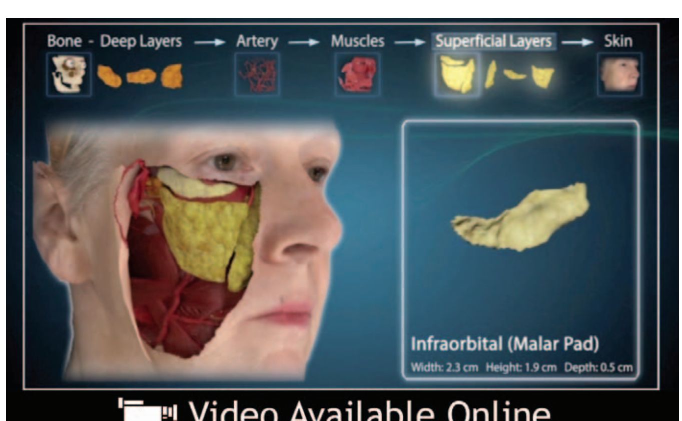


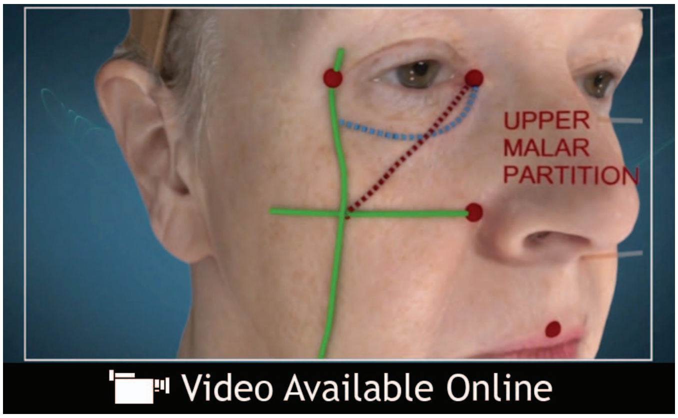
Fig. 6. Topographic facial analysis markings are displayed. Malar equator (*blue lines*); *LVR*, lateral vertical reference (*pink lines*); *MVR*, medial vertical reference (*green lines*); *UMP*, upper malar partition (*orange lines*); *LMP*, lower malar partition (*yellow lines*); *black rectangle*, upper malar adverse event zone; *AEZ*, lower malar adverse event zone; *MED*, medial malar target area; *MID*, middle malar target area; *LAT*, lateral malar target area.

The roof is the obliquely oriented orbitomalar ligament. The space is bordered inferiorly by a fibrous network of zygomaticocutaneous ligaments and maxillary insertions of the orbicularis oculi forming a discernible capsule as previously reported by Mendelson[30] (Figs. 4 and 10 through 12). This fascial encasement coalesces with the thick and well-demarcated capsule of the preperiosteal fat to form a uniform prezygomatic space capsule. Adherent to the undersurface of the orbicularis oculi and superficial to the capsule is the loose and areolar sub–orbicularis oculi fat (Fig. 10). The prezygomatic space is a trapezoidal space, which becomes crescentoid during facial animation. The medial and middle superficial fat compartments were found to be fibrofatty in composition (Fig. 10). Both superficial compartments become thicker and denser laterally in the midface. Manual superolateral traction on the superficial compartment layer demonstrated ease of movement of the medial superficial cheek compartment over the suborbicularis contents. This gliding movement simulates the sequence occurring during facial animation. (**See Video, Supplemental Digital Content 1,** which shows the conceptual description of the midfacial anatomical architecture, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B272***.)

In an attempt to demonstrate the accessibility of this pocket through percutaneous injection, red-dyed hyaluronic acid filler was injected into this region before dissection in selected specimens (Figs. 8 and 12). To target this space, the cutaneous insertion of the zygomaticocutaneous ligaments was used as a guide for finding a point inferolateral to this surface anatomy (Fig. 1). The zygomaticocutaneous ligaments arborize through the orbicularis inserting onto the skin. Cephalic to this skin insertion and superficial to the orbicularis lies the infraorbital "malar" fat compartment (Fig. 2). Understanding this depth relationship is important because injections placed in the infraorbital compartment are



Video 1. Supplemental Digital Content 1 shows the conceptual description of the midfacial anatomical architecture, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B272***.



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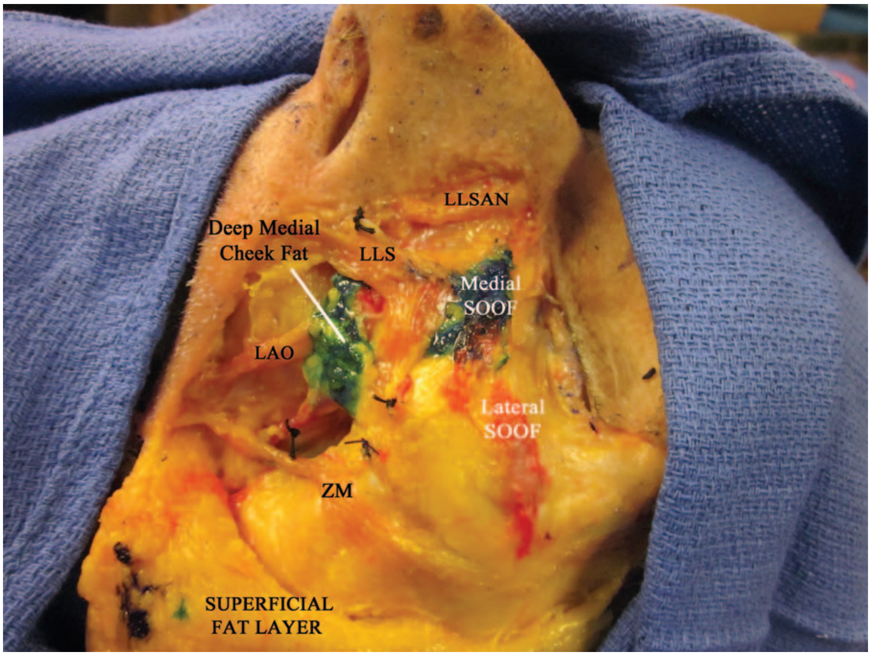

Fig. 7. Lateral view showing that the superficial fat compartment layer has been reflected. Demonstration of the deep medial cheek fat and medial sub–orbicularis oculi fat (*SOOF*) stained with methylene blue. Zygomaticus major (*ZM*), levator anguli oris (*LAO*), levator labii superioris (*LLS*), and levator labii superioris alaeque nasi (*LLSAN*) are labeled. Hyaluronic acid filler homogenized with red dye has been injected into the lateral sub–orbicularis oculi fat overlying the preperiosteal fat compartment.

prone to poor aesthetic outcomes secondary to diminished lymphatic drainage in this region.[25] This can result in iatrogenic malar mounds (Fig. 1). In this study, blunt cannulas consistently arrived at the deep prezygomatic space, positioned posterior to the orbicularis and anterior to the dense capsule of the preperiosteal fat (Figs. 11 and 12).

We postulate that the loss of volume proposed by Lambros occurs in the medial sub–orbicularis oculi fat and lateral sub–orbicularis oculi fat, contributing to the formation of the malar mound. Given the position and loose consistency of the sub–orbicularis oculi fat, targeted augmentations can be challenging. The specimens in this study had well-volumized fat within the tight

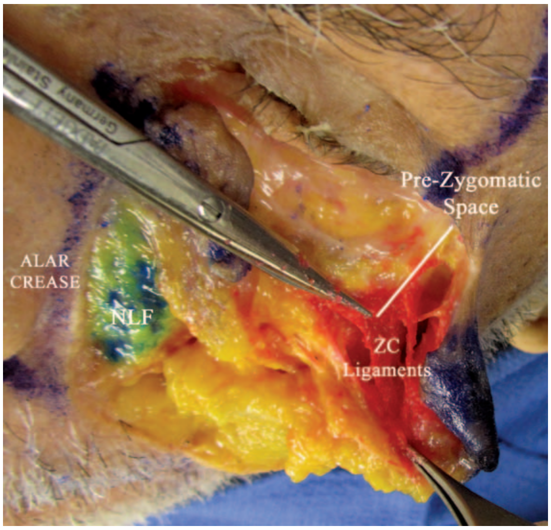

Fig. 8. Oblique view showing the nasolabial fat compartment (*NLF*) stained with methylene blue for a reference point. Injected red dyed filler is demonstrated in the prezygomatic space. The zygomaticocutaneous (*ZC*) ligaments are demonstrated forming the inferior border of the gliding prezygomatic space.

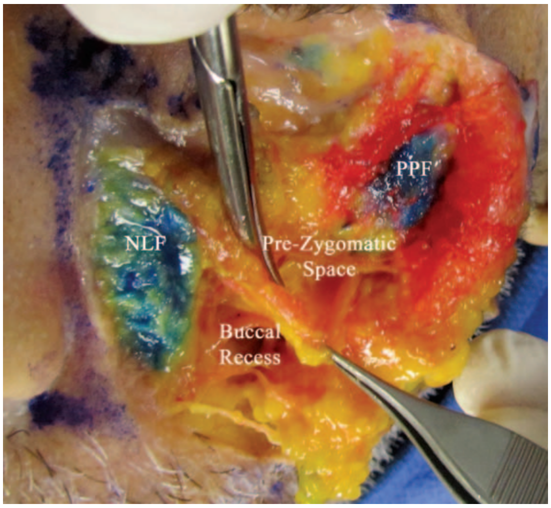

Fig. 9. Frontal view showing the nasolabial fat (*NLF*) and preperiosteal fat (*PPF*) compartments stained with methylene blue. The caudal margin of the prezygomatic space capsule is retracted by the forceps, and scissors are placed in the prezygomatic space. The cavernous communication into the buccal fat recess is observed inferior to the zygomaticocutaneous ligaments. This communicating space is a potential lower malar adverse event zone.

capsule of the preperiosteal fat (Figs. 7, 9, 11, and 12). Simple volumizing of the preperiosteal fat does not yield a dynamic aesthetically pleasing augmentation, a finding consistent with the long-term results of subperiosteal cheek implant placement. This region can be augmented in a static fashion; however, augmentation within the prezygomatic space may achieve an optimal congruency of projection through various phases of facial animation, facilitating a consistent rejuvenation as the superficial compartments glide over the deep compartments. (**See Video, Supplemental Digital Content 1,** which shows the conceptual description of the midfacial anatomical architecture, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B272***.) This avoids "double folds" seen with animation in patients who have received improper filler placement.

The position of the zygomaticofacial vascular bundle was noted and cross-referenced with previous studies.[4,15] This bundle was found to run within the zygomatic retaining ligament (MacGregor patch).[4] As described previously, this ligament corresponds with a central point of fixation and coalescence of several fat compartments.[25] The location of the infraorbital artery was consistent with previous studies. Pessa and Rohrich describe the junction of the lid-cheek crease and nasojugal crease as a suitable topographic landmark to identify the emergence of this bundle (Figs. 4 and 5).[25] Injectors must be cognizant of the descending infraorbital artery. The artery assumes a more superficial course during descent, facilitating safe entrance into the deep medial cheek fat from a deep plane (Figs. 5 and 7). During our dissections, an ascending branch of the infraorbital artery was noted traversing over the preperiosteal fat. This has been previously described as the palpebral branch of the infraorbital artery.[26] Hwang et al. reported the location of the palpebral branch of the infraorbital artery to be approximately half the eye width from the medial canthus[26] (Figs. 4 and 11). This artery is a potential bleeding risk following release of the arcus marginalis during a midface lift, fat transposition, and blepharoplasty procedures. Injection into the vessel or tamponading of the vessel can lead to undesirable postprocedural complications. (**See Video, Supplemental Digital Content 2,** which is a demonstration of a topographic analysis for midface volumization procedures, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B273***.)

In our study, we found the area between the pupil and medial corneal limbus to be a good visual reference for the course of the artery (Figs. 4 and 6). Medial to this reference point is the superior portion of the nasolabial fat compartment and

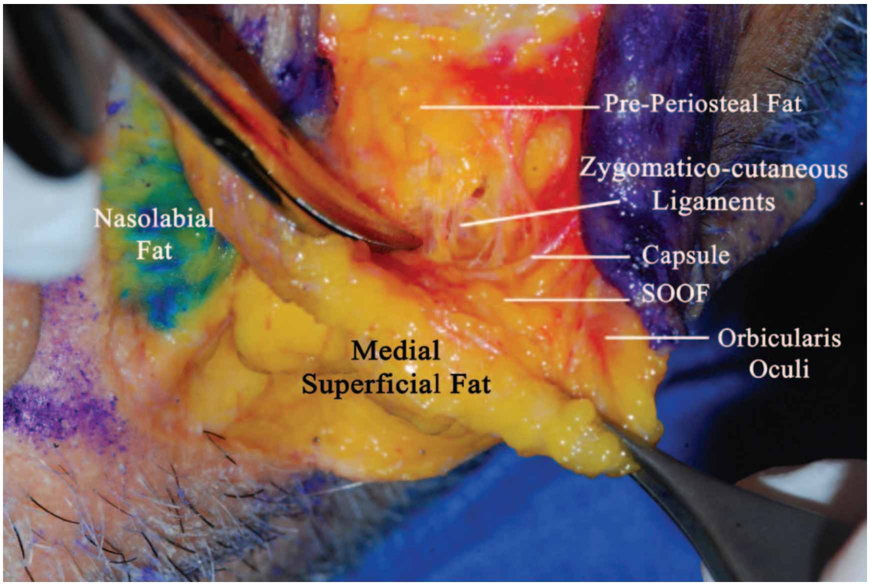

Fig. 10. Oblique view showing the nasolabial fat compartment stained with methylene blue for anatomical reference. The medial superficial fat compartment is seen as a separate layer from the deeper compartments. The instrument is inserted into the prezygomatic space. The inferior boundary of the space consists of a fibrous network of zygomaticocutaneous ligaments. The sub–orbicularis oculi fat (*SOOF*) lies on the undersurface of the orbicularis oculi, superficial to the prezygomatic space capsule. The preperiosteal fat is visualized on the bone.

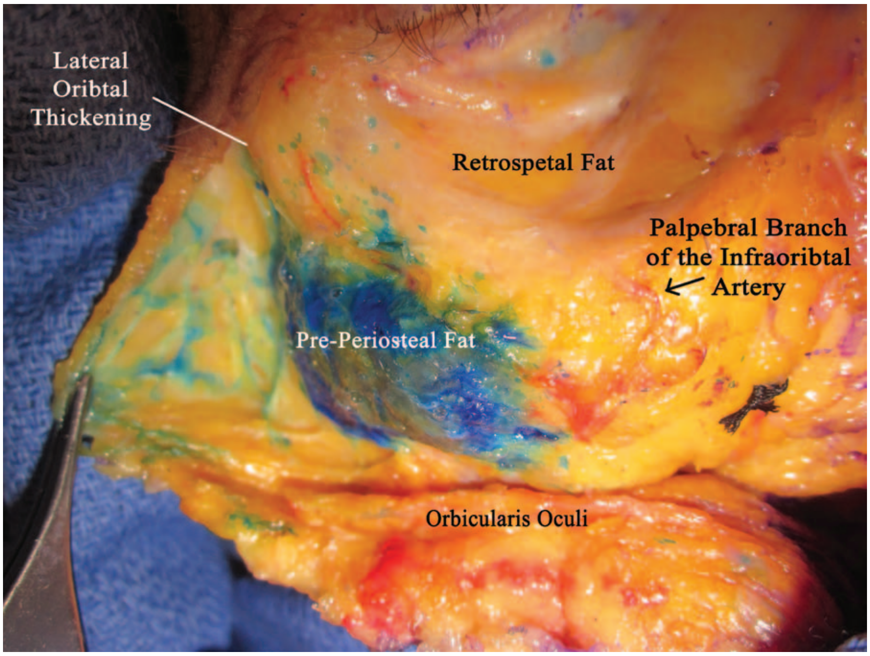

Fig. 11. Frontal view showing retroseptal fat and orbicularis oculi muscle labeled for anatomical reference. The lateral orbital thickening is shown as the adherent lateral border of the prezygomatic space. The preperiosteal fat has been stained with methylene blue and is noted in the floor of the prezygomatic space. The palpebral branch of the infraorbital artery is noted coursing through the medial sub–orbicularis oculi fat compartment.

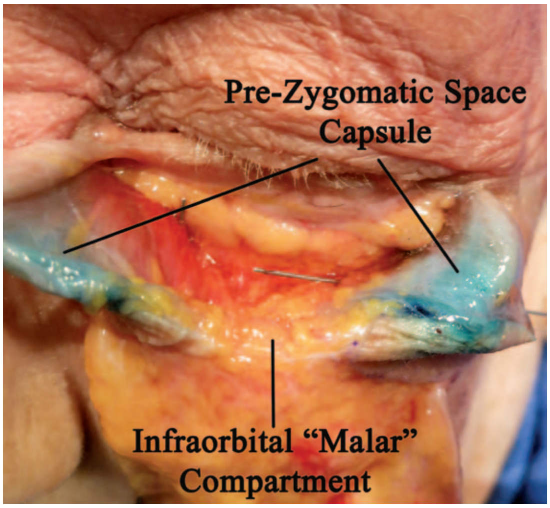

Fig. 12. Frontal view showing the prezygomatic space capsule stained with methylene blue. The infraorbital "malar" fat compartment is noted superficial to the prezygomatic space and orbicularis oculi. Blunt cannulas placed percutaneously before dissection are found inside the prezygomatic space.

the medial boundary of the prezygomatic space (Figs. 4 and 8 through 10).

Part 2: Midfacial Analysis

The described facial analysis uses easily identifiable topographic landmarks and simultaneously incorporates critical anatomical principles in the midface. We recognize that variation will exist among patients and that this can lead to "adverse event zones" and "target zones" existing outside the defined borders in this analysis. However, we feel that this anatomical outline encourages injectors to consider these areas during preprocedural planning and can assist in controlled, accurate record-keeping in volumizing procedures (Figs. 4 and 6). (**See Video, Supplemental Digital Content 2,** which is a demonstration of a topographic analysis for midface volumization procedures, available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B273***.)

Step 1: Malar Equator

The malar equator is a horizontal line drawn from the base of the alar crease partitioning the midcheek into upper and lower regions based on key anatomical relationships (Figs. 4 and 6).

Step 2: Lateral Vertical Reference

A vertical line drawn from the lateral orbital rim to the angle of the mandible delineates the anterior "mobile" face from the lateral "immobile" face (Figs. 4 and 6).[28] This corresponds with the lateral orbital thickening, a tight adherence of fascia that serves as the lateral boundary of the prezygomatic space (Fig. 11).

Step 3: Upper Malar Partition

The upper malar partition is an oblique line drawn from the medial canthus to the junction of the first two analysis lines (malar equator and lateral vertical reference). This functions as a dividing line for medial, middle, and lateral malar target areas (Figs. 4 and 6). The medial malar target area contains the superior segment of the nasolabial fat compartment (Figs. 8 through 11). The middle malar target zone isolates structures in the superficial and deep fat layers. Superficially, the medial superficial cheek compartment can be targeted (Fig. 10). In the deep compartment layer, the medial segment of the prezygomatic space can be isolated (Figs. 7 and 8). The lateral malar target area isolates the infraorbital compartment superficially (Fig. 12). In the deep compartment layer, the lateral segment of the prezygomatic space can be targeted (Figs. 4, 10, and 11). Lastly, this partition will assist in preprocedural prediction for the location of the palpebral branch of the infraorbital artery (Figs. 4, 6, and 11).

Step 4: Lower Malar Partition

The lower malar partition is an oblique line drawn from the modiolus to the junction of the first two analysis lines (malar equator and lateral vertical reference) (Figs. 4 and 6). This topographic line corresponds with the approximate course of the zygomaticus major muscle, the origin of which was 4.6 cm from the base of the alar crease in this study (Table 1). The lower malar partition represents the lateral border of a cavernous space in the lower midface communicating with the buccal fat compartment (Figs. 8 and 9). Given our clinical observations and others' clinical observations of jowling in select patients who underwent attempted deep medial cheek compartment augmentation, we believe this space to be a potential adverse event zone (Figs. 3 through 5, 7, and 8).[29] We have therefore named this area the lower malar adverse event zone (Figs. 5 through 7). The medial border of this space is defined in the next step of the analysis.

Step 5: Medial Vertical Reference

The medial vertical reference is a vertical line drawn from the medial pupillary border to the upper lip (Figs. 4 and 6). Topographically, this marking corresponds with the lateral border of the levator anguli oris muscle, which lies approximately 2.6 cm from the base of the alar crease (Table 1). The medial vertical reference is critical for multiple reasons. First, it functions as the medial border of the lower malar adverse event zone (Figs. 4 through 6). The region medial to this line is where we recommend injectors target the deep medial cheek fat compartment, as this is where the compartment is most compact and may decrease the chance of filler migration laterally into the lower malar adverse event zone (Figs. 5 and 7). As the line ascends into the upper malar region it will intersect with the upper malar partition (Figs. 4 and 6). Topographically, this intersecting region represents the location of the ascending palpebral branch of the infraorbital artery. We have clinically observed intraarterial injections of this vessel following a volumizing procedure and therefore have delineated this intersection a potential upper malar adverse event zone (Figs. 5, 6, and 11).

CONCLUSIONS

A sound understanding of the midfacial anatomy is essential to achieve optimal filler or fat augmentation and minimize adverse outcomes. This cadaveric study yields a detailed visual representation of critical anatomical relationships in the midface. We define the clinical relevance of the prezygomatic space, palpebral branch of the infraorbital artery, and facial fat compartments as they relate to facial injections and fat grafting. We address the anatomical relationships involved in iatrogenic malar mounds. The described stepwise analysis provides surgeons with a scientific system to identify adverse event zones and safe harbors in midface augmentation. These zones are not absolute, as each patient is unique. This information offers the aesthetic surgeon an anatomically inspired outline to assist in the delivery of safe, accurate, and reproducible dynamic rejuvenation through volumization.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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