Three-Dimensional Topographic Surface Changes in Response to Volumization of the Lateral Suborbicularis Oculi Fat Compartment

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Background: Autologous fat grafting is an increasingly preferred method for aesthetic facial rejuvenation. The authors' group previously described the concept of "lipotopography" as topographic surface changes that occur with fat grafting to discrete facial fat compartments. The purpose of this study was to define the "augmentation zone" of the lateral suborbicularis oculi fat compartment to understand the topographical surface changes following augmentation.

Methods: Nine cadaver hemifaces were injected with fat analogue at intervals from 1 to 4 cc. Three-dimensional photographs were taken at baseline and following each 1-cc incremental injection. The interval surface changes were calculated using three-dimensional software including perimeter, diameter, and projection.

Results: The augmentation zone of the lateral suborbicularis oculi fat compartment was characterized by a consistent shape and boundary. The shape was an elongated oval bound superiorly by the lid-cheek junction and inferiorly at the level of the zygomaticocutaneous ligament. Vertical and horizontal diameter and perimeter showed initial increases between 1 and 2 cc and then a plateau between 2 and 3 cc. Projection changes demonstrated an initial slow increase from 1 to 2 cc injection followed by nearly linear growth from 2 to 4 cc.

Conclusions: Three-dimensional photography and computer analysis provide tools to understand the surface anatomy change in response to fat grafting specific facial fat compartments. Targeted volumization of the lateral suborbicularis oculi fat compartment also results in a unique surface change with consistent shape and anatomical boundaries. The lid-cheek junction and zygomaticocutaneous ligament were observed to restrict the expansion of fat analogue for all injection volumes. (*Plast. Reconstr. Surg.* 145: 653, 2020.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, V.

Prior anatomical studies by Rohrich et al. demonstrated the existence of discrete fat compartments defined by fascial barriers within the superficial and deep layers of the face.[1–6] The architecture of individual fat compartments within a framework of dividing ligaments suggested that a systematic approach to facial augmentation was needed.[7–10] Objective documentation of facial soft-tissue changes has posed a challenge to plastic

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Received for publication September 8, 2018; accepted July 9, 2019.
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DOI: 10.1097/PRS.0000000000006592

Disclosure: *None of the authors has a financial interest in any of the products or devices mentioned in this article.*

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surgeons analyzing the three-dimensional contour of the face.

Facial volume loss has been shown to contribute to aging changes with resultant descent of facial structure and deepening of the facial rhytides.[1,9] Therefore, volume restoration is critical in facial rejuvenation. Autologous fat grafting is increasingly used to improve facial aesthetics in the aging face and in posttraumatic patients who have a loss of facial fat and soft tissue. The relationship between volumization of specific compartments and the dynamic changes to facial contour on the surface remains largely unknown.

Our group previously described the concept of "lipotopography" as topographic surface changes that occur with fat grafting to discrete facial fat compartments.[11,12] There is growing interest in targeting the lateral cheek for malar augmentation to achieve a more youthful facial appearance. The purpose of this study was to define the zone of augmentation for the lateral suborbicularis oculi fat compartment and elucidate the relationship between incremental volumes of injection and the corresponding topographic surface changes observed. These data contribute to the overall understanding of compartmental volumization for aesthetic rejuvenation in facial aging. [**See Video 1 (online)**, which shows a cadaveric dissection demonstrating the lateral suborbicularis oculi fat compartment. Blue dyed Restylane (Q-Med, Uppsala, Sweden) is injected into the lateral cheek compartment, demonstrating the dynamic expansion of the compartment, which contains the volume within its boundaries.]

PATIENTS AND METHODS

Injection Technique

Lateral suborbicularis fat compartment volumization was performed in a cadaveric model (n = 9). Applesauce was used as an autologous fat analogue because the physical properties (e.g., resistance, aspiration rate, and viscosity) have been shown to correlate with aspirated autologous fat in vivo.[13] For injection, 1-cc syringes with 18-gauge needles were used. Injection technique was guided by prior work on cadaveric studies, and the port was marked systematically on all cadavers according to the described technique.[14,15] Stepwise injections to the lateral cheek were performed and studied at 0.5-, 1-, 2-, and 4-cc total volumes.

Three-Dimensional Photography and Computer Analysis to Define the Augmentation Zone

Three-dimensional photographs were taken using the hand-held Canfield VECTRA H1 (Canfield Scientific, Parsippany, N.J.) system in the method described in our previous study on the medial cheek augmentation zone.[11] Three-dimensional photographs where taken before injection, which served as the baseline image of reference. Three-dimensional photographs were then taken following each injection volume at the intervals described.

To define the unique surface change for given volumes of fat analogue to the lateral cheek compartment, "overlay" models were created using Canfield VECTRA Analysis Module software using a method similar to that described previously. The overlay is a merged three-dimensional model consisting of the baseline (preinjection) three-dimensional image and the augmented three-dimensional image (following discrete volume of injection). This is performed manually by identifying facial surfaces that are identical across injected models (forehead, nose), and then performing computer recognition of these surfaces to merge the two three-dimensional images precisely.

To visualize the pattern of surface change, color maps that represent topographic differences between the augmented and baseline three-dimensional photographs were generated (Fig. 1). The color maps were created by defining 1-mm change in projection as the lower limit of surface change, and the maximum projection value (calculated by the computer) as the upper limit of surface change. We call this new surface change the "augmentation zone."

To further define the augmentation zone for the lateral suborbicularis oculi fat compartment, the perimeter, maximum horizontal and vertical diameter (vector distance), and projection were measured. Mean values were calculated with a two-tailed paired t test relating values to the previous injection value, and a value of $p < 0.05$ was considered statistically significant.

RESULTS

Volumization Creates a Zone of Augmentation with a Unique Shape

Volumization of the lateral suborbicularis oculi fat compartment led to unique topographical changes. The augmentation zone was characterized by consistent shape and boundaries across

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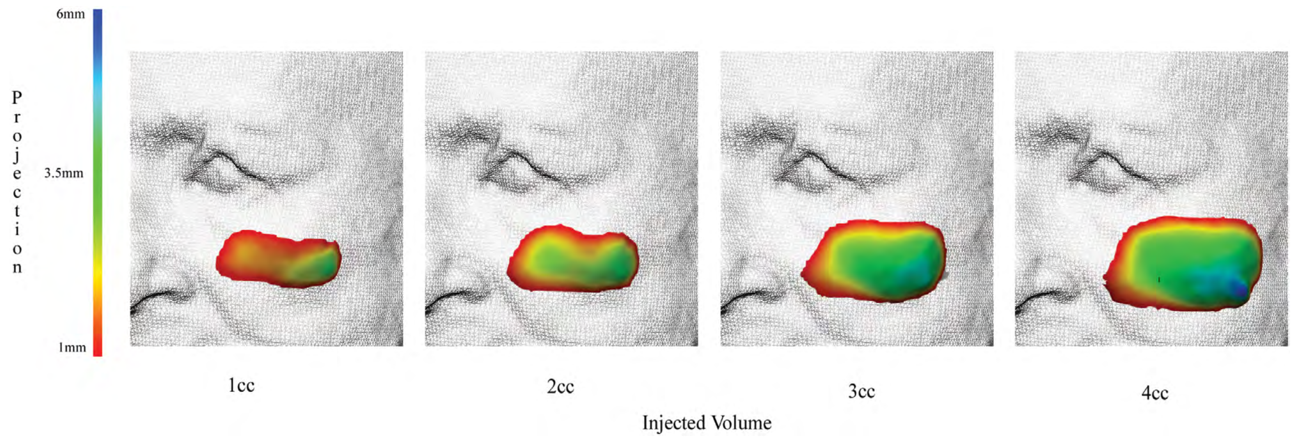

Fig. 1. Color topographic map showing interval injection volumes to the lateral orbicularis oculi fat compartment. Injections of 1 to 4 cc are shown in progression from *left* to *right*. A minimum change in anterior projection was set at 1 mm (*red*) and a maximum of 6 mm of projection is achieved (*blue*).

all cadavers. The shape was on elongated oval that was bound superiorly by the lid-cheek junction and inferiorly at the level of the zygomaticocutaneous ligament (Fig. 2).

Defining the Augmentation Zone of the Lateral Suborbicularis Oculi Fat Compartment

In addition to defining the shape of the augmentation zone, we analyzed other topographic measurements to better understand the three-dimensional contour achieved by incremental augmentation of the lateral suborbicularis oculi fat compartment (Table 1). The horizontal diameter was consistently greater than the vertical diameter. This was the mechanism behind the elongated ellipse shape of the lateral suborbicularis oculi fat compartment that was observed across samples (Fig. 2). Perimeter and diameter showed initial increase between 1 and 2 cc and a plateau between 2 and 3 cc. The horizontal diameter (horizontal diameter, 31.2 ± 6.9 mm, 41.6 ± 5.3 mm, 43.9 ± 2.5 mm; vertical diameter, 21.9 ± 4.5 mm, 27.25 ± 6.1 mm, 31.6 ± 8.2 mm; perimeter 124.2 ± 14.4 mm, 153.2 ± 7.0 mm, 172.1 ± 7.0 mm for 1-, 2-, and 3-cc injections, respectively) (Fig. 3).

Anterior projection underwent a different pattern of growth from the diameter and perimeter. There was an initial slow increase from 1 to 2-cc injection followed by nearly linear growth from 2 to 4 cc (3.2 ± 0.7 mm, 3.8 ± 0.8 mm, 4.5 ± 1.2 mm, and 5.3 ± 1.4 mm, respectively) (Fig. 4). The volume change calculated at interval injections increased in a constant pattern consistent with the volume quantity injected (Fig. 5).

DISCUSSION

The mechanism of facial aging is a topic of great interest in plastic surgery. Lambros's theory of facial aging suggested that aging is attributable to changes in soft-tissue support and skeletal remodeling, rather than vertical descent of soft tissue over time.[16] Lambros further observed that periorbital and midface structures were stable in position over time, and that volume loss rather than descent of tissues contributes to an aged appearance.[2] Thus, restoring volume loss is a therapeutic target in facial rejuvenation, in isolation or as an adjunct to other facial cosmetic procedures. Restoring volume to the facial fat compartments is a therapeutic target for facial rejuvenation and aims to restore structure and support to the aging midface. The approach to restoring volume to the face relies on thorough knowledge of the deep and superficial fat compartments of the face.

The description of discrete facial fat compartments by Rohrich and Pessa changed the approach to facial aging by describing a scaffold for soft-tissue augmentation.[9] The periorbital and malar region is composed of superficial and deep fat compartments. Studies by Rohrich et al. demonstrate the existence of three distinct deep facial fat compartments in the midface using radiopaque dyed injections. The dyed injections revealed the shape and boundaries of the deep medial cheek fat compartment and two suborbicularis oculi fat compartments, the medial suborbicularis oculi fat compartment and the lateral suborbicularis oculi fat compartment.[17] The lateral suborbicularis oculi fat compartment and its boundaries was further confirmed by dyed injections performed by Cotofana et al.[18] These anatomical dissections

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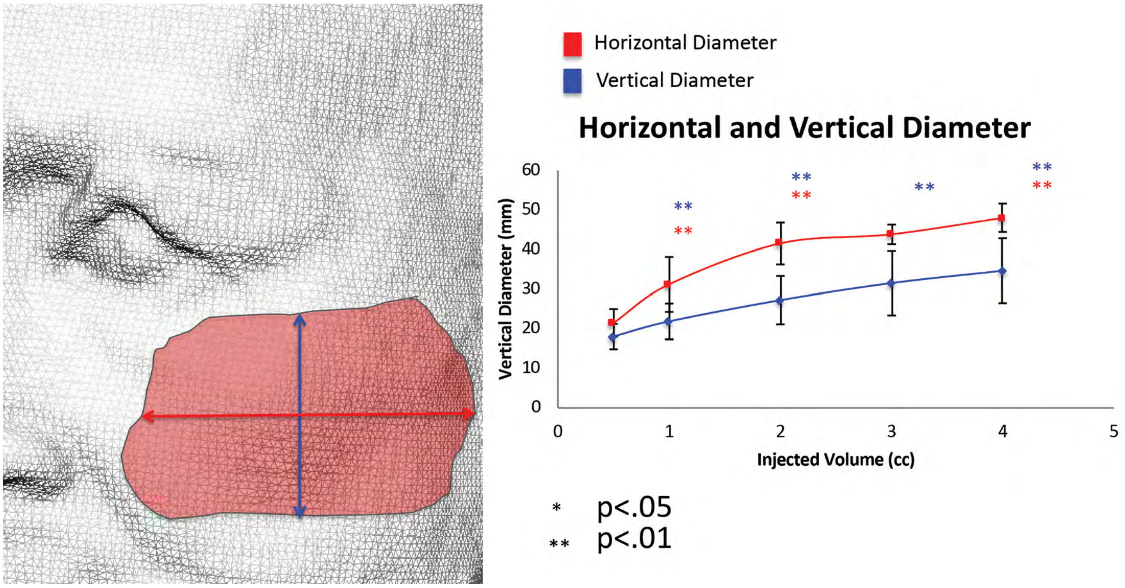

Fig. 2. The lateral suborbicularis oculi fat compartment augmentation zone horizontal and vertical diameter are shown for interval injections from 0.5 to 4 cc. (*Left*) A select example of the augmentation zone of the lateral suborbicularis oculi fat compartment. The progressive mean change in horizontal and vertical diameter are plotted (*right*).

Table 1. Lateral Suborbicularis Oculi Fat Compartment Augmentation Zone Metrics for Injection Volumes of 0.5 to 4 cc*

Injected Volume (cc)	Perimeter (mm)	Vertical Diameter (mm)	Horizontal Diameter (mm)	Anterior Projection (mm)	Surface Area (cm^2)	Volume (cc)
0.5	109.4 ± 31.7	18.1 ± 3.2	21.5 ± 3.5	2.9 ± 0.9	4.7 ± 1.2	0.7 ± 0.2
1.0	124.3 ± 14.4†	21.9 ± 4.5‡	31.2 ± 6.9‡	3.2 ± 0.7†	6.6 ± 0.6‡	1.1 ± 0.2‡
2.0	153.2 ± 8.6‡	27.3 ± 6.1‡	41.6 ± 5.3‡	3.8 ± 0.8‡	10.3 ±1.2‡	2.0 ± 0.4‡
3.0	172.1 ± 7.0‡	31.6 ± 8.2‡	43.9 ± 2.5	4.5 ± 1.2‡	13.4 ± 1.3‡	2.9 ± 0.4‡
4.0	187.9 ± 13.7‡	34.7 ± 8.2‡	48.1 ± 3.6‡	5.3 ± 1.4‡	16.3 ± 1.8‡	3.9 ± 0.7‡

*p value determined by comparison to prior injection volume.
†$p < 0.05$.
‡$p < 0.01$.

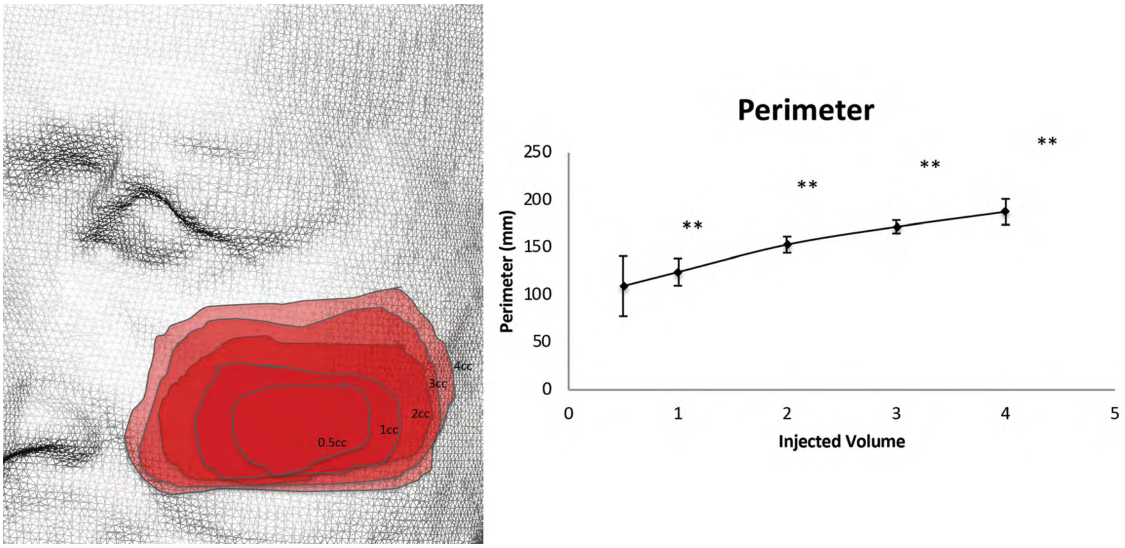

Fig. 3. Lateral suborbicularis oculi fat compartment augmentation zone perimeter change from 0.5- to 4-cc injection volumes. Progressive perimeter tracings for a select specimen (*left*) and the mean perimeter per injection volume (*right*).

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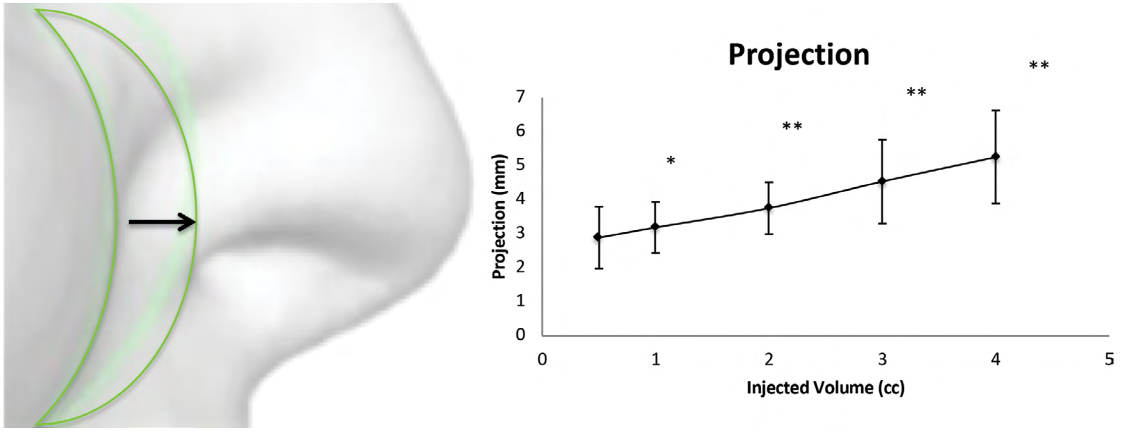

Fig. 4. Anterior projection of the lateral suborbicularis oculi fat compartment augmentation zone from 0.5- to 4-cc injection volume.

showed the lateral suborbicularis oculi fat compartment was bound superiorly by the orbital retaining ligament, inferiorly by the zygomaticocutaneous ligament, does not extend above the level of the lateral canthus, and extends laterally toward the temporal region. These findings correlate with the topography observed on the surface when volume is injected in the lateral suborbicularis oculi fat compartment in our study, visualized using three-dimensional surface scanning.

Understanding the anatomy of the facial fat compartments and the topographic contour change on the surface is needed to guide the surgical approach. Volume injection to the deep fat compartments of the periorbital region and midface provide support and restores volume loss. It is essential to treat multiple fat compartments in combination to restore the volume lost and correct the deflated appearance in this region.[12,19] Thus, understanding the surface topography of the fat compartments in isolation offers the surgeon an informed approach when determining the optimal combination of fat compartments to inject.

Our group previously described the surface topographic response to volumization of the deep medial cheek compartment. This study continues to elucidate the surface response to targeted injects by studying the lateral suborbicularis oculi fat compartment. In this study, we describe the augmentation zone of the lateral suborbicularis oculi fat compartment and its unique topographic surface change (Fig. 6). Three-dimensional photography and analysis objectively describe both visually by means of color mapping, and quantifiably by the various calculations described, a

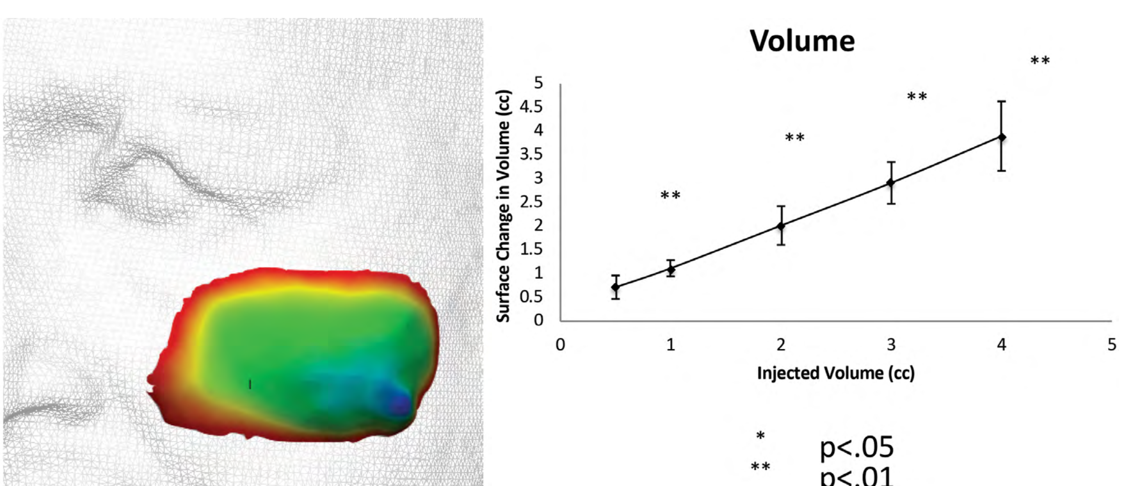

Fig. 5. Lateral suborbicularis oculi fat compartment augmentation zone calculated volume changes for given injected volume are shown. (*Left*) Surface change attributed to a 4-cc injection to the lateral cheek compartment. (*Right*) Computer-calculated volume change for progressive injection volumes from 0.5 to 4 cc.

Fig. 6. Cadaveric dissection demonstrating the anatomy of the lateral orbicularis oculi fat compartment, lateral suborbicularis oculi fat compartment (*blue*), and the deep medial cheek fat compartment (*green*). Note that the dyed fat analogue is contained within the fat compartments. The boundaries of the lateral suborbicularis oculi fat compartment are demonstrated to be the orbicular retaining ligament superiorly and the zygomaticocutaneous ligament inferiorly. *LSOOF*, lateral suborbicularis oculi fat compartment; *DMC*, deep medial cheek fat compartment.

reproducible surface change following lateral suborbicularis oculi fat compartment volumization.

The injected volume was placed into the lateral suborbicularis oculi fat pad, which lies just above the periosteum and deep to the orbicularis oculi muscle.[18] The superior border of the lateral cheek compartment was restricted by the lid-cheek junction, at the level of the orbital retaining ligament. Similarly, the inferior border of the lateral cheek compartment was restricted at the level of the zygomatic cutaneous ligament. [**See Video 2 (online)**, which demonstrates the dynamic injection of the lateral suborbicularis oculi fat compartment with fat analogue. Note the well-circumscribed and elongated oval shape of the compartment when injected. **See Video 3 (online)**, which demonstrates the dynamic injection of the deep medial cheek compartment with fat analogue. **See Video 4 (online)**, which demonstrates the reflection of the superficial musculoaponeurotic system revealing the individual deep medial cheek fat compartment medially, and the lateral suborbicularis fat compartment laterally. Note the shape and size of the restricting boundaries of the individual fat compartments.]

Interestingly, the horizontal and vertical dimensions of the lateral cheek augmentation zone reached plateau between 2- and 3-cc injection volumes, whereas the greatest increase in anterior projection occurred between 2- and 4-cc injection volumes. This implies that low volumes (1 to 2 cc) initially fill the fat compartment in a horizontal and vertical dimension (i.e., on the x and y axes) until a perimeter limit or footplate is reached and only then leading to an increase in anterior projection, or z axis. It may be inferred from this finding that the restricting perimeter observed in these cadaveric studies are the retaining ligaments of the face as described previously.[1]

There are limitations to this study. This was a cadaveric study with a small sample size. In addition, many variables impact facial augmentation, including patient factors and filler material (i.e., autologous fat versus filler). Preliminary data suggest patient-specific factors impact the dynamics of facial fat compartments in response to augmentation. Numerous variables such as skin quality, fat processing, fat resorption, and changes over time are important concepts in fat grafting. The viability of fat in the facial fat compartments is a topic of ongoing investigation. To generate a fat grafting algorithm where injection volume can be correlated with surface response (i.e., surface area, perimeter, anteroposterior projection), a larger sample size of cadavers and ultimately clinical patients is needed for subgroup analysis.

This study aims to define the consistent outline and surface topography of the lateral suborbicularis oculi fat compartment. Although these injections are frequently used in surgical venues, the exact surface change has not been objectively defined. This article is a continuation of mapping the individual facial fat compartments and their unique surface topographic changes following incremental volume injections. Our group previously defined the surface topography of the deep medial cheek compartment. In addition, the "boomerang lift" technique, described by our group, highlights the importance of combining multiple malar fat compartments to achieve a restored cheek aesthetic.[12] The lateral suborbicularis oculi fat compartment contributes to the reestablishment of facial contour by providing lateral fullness that extends along the zygomatic arch, or the "tail" of the boomerang shape. This helps to restore the rectangular facial shape developed with volume loss to the heart-shaped appearance of youth.

CONCLUSIONS

Three-dimensional photography and computer-based analysis effectively document the

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change to the facial topography attributable to incremental injections in discrete compartments. By way of three-dimensional photography, we are able to document precise change to the facial contour in response to volumization of individual fat compartments. This information will lead to a better understanding of volumetric changes and to the development of surgical algorithms for facial augmentation.

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ACKNOWLEDGMENT

The authors thank Fusion Medical Education.

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