The Functional Anatomy of the Superficial Fat Compartments of the Face: A Detailed Imaging Study

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Background: The superficial (subcutaneous) facial fat compartments contribute to the signs of facial aging, but a comprehensive anatomical description of their location and their functional behavior during the application of soft-tissue fillers remains elusive.

Methods: The authors investigated 30 fresh frozen cephalic specimens from 13 male and 17 female Caucasian body donors (age, 78.3 ± 14.2 years; body mass index, 23.1 ± 5.3 kg/m^2). Upright-position, contrast-enhanced computed tomographic scanning, and additional magnetic resonance imaging were performed. Three-dimensional reconstruction–based measures were conducted to evaluate the position of the applied contrast agent in each compartment separately. Successive anatomical dissections were performed to confirm the imaging findings.

Results: Positive correlations were detected between the amounts of injected material and the inferior displacement for the superficial nasolabial ($r_p = 0.92$, $p = 0.003$), middle cheek ($r_p = 0.70$, $p = 0.05$), and jowl ($r_p = 0.92$, $p = 0.03$) compartments but not for the medial cheek ($r_p = 0.20$, $p = 0.75$), lateral cheek ($r_p = 0.15$, $p = 0.75$), or the superior ($r_p = -0.32$, $p = 0.41$) or inferior superficial temporal compartment ($r_p = -0.52$, $p = 0.29$).

Conclusion: This study confirms the presence of distinct subcutaneous fat compartments and provides evidence for an individual behavior when soft-tissue fillers are applied: inferior displacement of the superficial nasolabial, middle cheek, and jowl compartments, in contrast to an increase in volume without displacement (i.e., an increase in projection) of the medial cheek, lateral cheek, and both superficial temporal compartments. (*Plast. Reconstr. Surg.* 141: 1351, 2018.)

Injectable soft-tissue fillers have become a popular and widely accepted method of ameliorating the signs of facial aging. According to statistics released in 2016 by the American Society of Plastic Surgeons, there was an increase of 298 percent between the years 2000 and 2016 in minimally invasive applications of soft-tissue fillers.[1]

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Received for publication June 27, 2017; accepted December 28, 2017.

DOI: 10.1097/PRS.0000000000004364

Since 2007, when the superficial (subcutaneous) facial fat compartments were introduced,[2] several studies have further increased our understanding of their anatomical location and

Disclosure: *None of the authors listed has commercial associations or financial disclosures that might pose or create a conflict of interest with the methods applied or the results presented in this article.*

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their age-related changes.[3–11] However, contradicting results have been presented with regard to nomenclature and volumetric changes of the superficial facial fat compartments during aging. Although Gosain et al.[12] concluded that selective hypertrophy of the upper portion of the cheek fat pad presented as a sign of aging when assessed by magnetic resonance imaging, Le Louarn et al.[13] attributed the observed increase in volume on magnetic resonance imaging scans to a displacement of the deep fat from beneath the muscle plane toward more superficial layers. In a recent contrast-enhanced computed tomography–based investigation, Gierloff et al.[4] presented an inferior migration of the midfacial fat compartments and an inferior volume shift within the compartments during aging. Conversely, Wysong et al.[14,15] used magnetic resonance imaging scans of both men and women to demonstrate a decrease in volume in the infraorbital area and in the medial and lateral cheeks and concluded that facial soft tissue undergoes significant deterioration during the aging process. Finally, Corey et al.[16] found no significant correlations between age and the ratio of total malar volume to body mass index; they concluded that ptosis of midfacial fat is more important than volume loss in midfacial aging.

One possible explanation for the inconsistent results of the previous studies is that the superficial facial fat compartments were not investigated on an individual basis, but rather on a group or regional basis. It might be possible also that the behavior of the compartments is different during aging depending on their location: some may change their position, whereas others may remain stable because of their ligamentous connections to the underlying bone.

As the superficial fat compartments are distinct and separated from each other by septa,[2–5,7–10,17–19] analyses should be conducted according to their precise anatomical location. This would allow the description of specific changes of each compartment individually and ultimately enable practitioners to treat on a more detailed basis.

The objective of the present study was to describe the precise location of the superficial (subcutaneous) facial fat compartments and their relationship to relevant clinical landmarks and to investigate the changes during aging of each of these fat compartments by using contrast-enhanced computed tomographic and T1 and T2 magnetic resonance imaging combined with anatomical dissections.

PATIENTS AND METHODS

Sample

We investigated 30 fresh frozen cephalic specimens from 13 male and 17 female Caucasian body donors with a mean age of 78.3 ± 14.2 years and a mean body mass index of 23.1 ± 5.3 kg/m^2. Age details were as follows: three male and three female body donors aged 60 to 69, 70 to 79, 80 to 89, 90 to 99 years; three body donors older than 100 years; and three body donors younger than 60 years. Specimens were screened and not included in this analysis if previous facial surgery or diseases disrupted the integrity of the facial anatomy. Each body donor had given informed consent while alive for the use of his or her body for medical, scientific, and educational purposes.

Injection Procedure

The superficial (subcutaneous) facial fat compartments (superficial nasolabial, superficial medial cheek, superficial middle cheek, superficial lateral cheek, jowl, and superficial superior and superficial inferior temporal) were injected using a 20-gauge, 70-mm, sharp-tip needle. The injection procedure was based on transcutaneous (perpendicular to the skin surface) applications of colored radiopaque material. The injected material consisted of iodixanol (Visipaque 320, 320 mg/ml; GE Healthcare, Little Chalfont, United Kingdom), Resource ThickenUp Clear (Nestle HealthCare Nutrition GmbH, Vienna, Austria), and commercially available food coloring. The viscoelastic properties were compared to commercially available soft-tissue fillers to ensure similar rheologic behavior. The amount of the implanted material was visually controlled during the injection procedure to achieve maximal filling of the respective compartment and to simulate the effects of facial aging.

Radiographic Imaging

Computed tomographic scans were obtained in the upright position using a headrest to simulate the effects of gravity. The following computed tomography parameters were applied: slice thickness, 0.6 mm; field of view, 200 mm; increment, 0.5 mm; voltage, 140 kV; and current 400, mA/second (Fig. 1).

Magnetic resonance scans were obtained in the supine position because of spatial limitations of the head coil used, and the following magnetic resonance imaging parameters were applied: sagittal T1 Vista (field of view, 270 × 270 × 205 mm; voxel size, 0.7 × 0.7 × 0.35 with a voxel size of 0.352 mm; signal-to-noise ratio, 1.0; echo time,

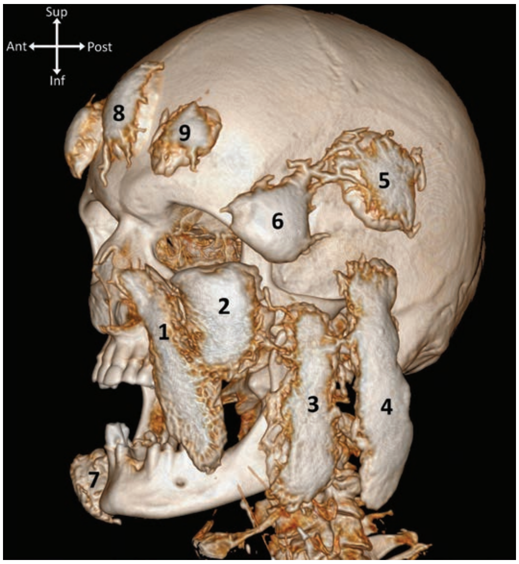

Fig. 1. Three-dimensional reconstruction of a contrast-enhanced computed tomographic scan. The superficial (subcutaneous) facial fat compartments have been injected: superficial nasolabial (*1*), medial cheek (*2*), middle cheek (*3*), lateral cheek (*4*), superficial superior temporal (*5*), superficial inferior temporal (*6*), and jowl (*7*). The superficial central (*8*) and the superficial lateral (*9*) forehead compartments have also been visualized in this image.

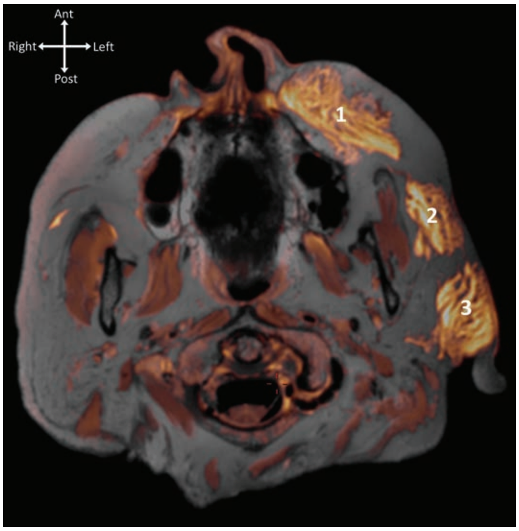

Fig. 2. T1 and T2 fused magnetic resonance image in the transverse plane showing the superficial nasolabial fat compartment (*1*), the middle cheek fat compartment (*2*), and the lateral cheek fat compartment (*3*). Note that the transverse section is below the level of the medial cheek fat compartment and above the jowl fat compartment.

18 msec; repetition time, 350 msec; 586 slices per data set) and T2 three-dimensional short tau inversion recovery (field of view, 270 × 270 × 204 mm; voxel size, 0.9 × 0.9 × 0.45 with a voxel size of 0.422 mm, signal-to-noise ratio, 1.0; echo time, 308 msec; repetition time, 3000 msec; 454 slices per data set) (Fig. 2).

Anatomical Dissections

Cephalic specimens were dissected after the imaging procedures at the Surgical Course Center, Salzburg, Austria, and dissection procedures were facilitated by the previously injected colored material (Fig. 3).

Analysis Strategy

On three-dimensional computed tomographic reconstructions, the maximal vertical and horizontal extent of each compartment was measured. The precise location was evaluated in relation to the midline (distance between the midline and the most medial and the most lateral aspect), and to a horizontal line at the level of the root of the nose (sella-nasion horizontal plane) or the zygomatic arch. Computed tomographic scans were aligned to the sella-nasion horizontal plane to ensure consistency between measurements.

Quantifications and numerical analyses were generated exclusively from measurements taken from the upright three-dimensional computed tomographic reconstructions, whereas magnetic resonance imaging was used to better visualize the anatomical boundaries of the compartments and their relationships to adjacent anatomical structures. Correlations between the amount of injected volume and the displacement of the superior/inferior aspect of the contrast agent within each superficial (subcutaneous) fat compartment was calculated by means of bivariate correlations (Pearson, r_p), and influences of age and body mass index were computed by means of generalized linear models using IBM SPSS Version 23 (IBM Corp., Armonk, N.Y.). Results were considered statistically significant at a probability level of $p \leq 0.05$ to guide conclusions.

RESULTS

Superficial Nasolabial Compartment

The volume injected until maximal filling was achieved was 11.1 ± 4.6 cc; this resulted in a vertical size of the compartment of 65.7 ± 13.6 mm and a horizontal size of 65.7/35.0 ± 6.1 mm (Figs. 1 through 4). [**See Video, Supplemental Digital Content 1**, showing manual movement of the superficial (subcutaneous) facial fat compartments to demonstrate the mobility after dye has been

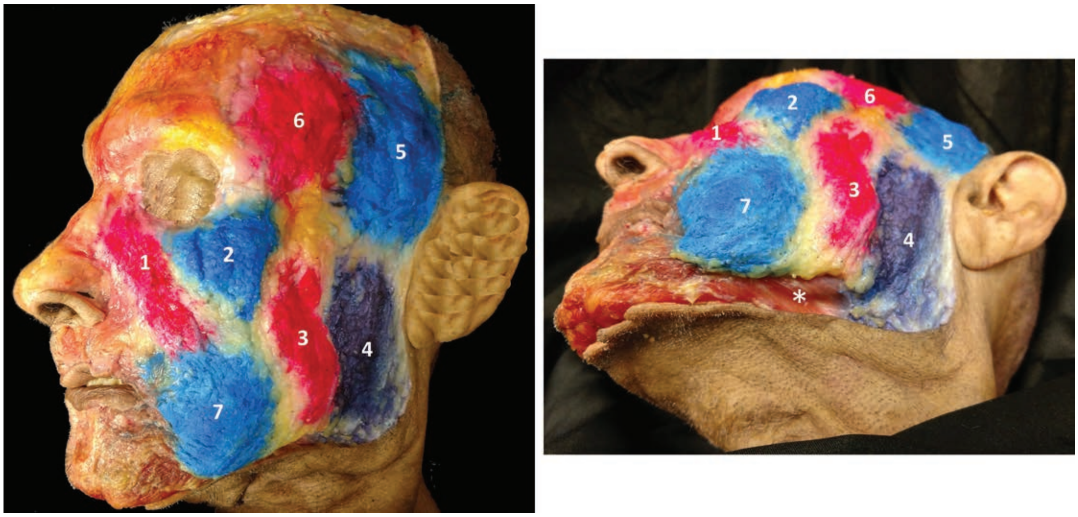

Fig. 3. (*Left*) Cadaveric dissection of the left side of a face after the superficial (subcutaneous) fat compartments have been injected with colored dye: superficial nasolabial (*1*, *red dye*), medial cheek (*2*, *blue dye*), middle cheek (*3*, *red dye*), lateral cheek (*4*, *violet dye*), superficial superior temporal (*5*, *blue dye*), superficial inferior temporal (*6*, *red dye*), and the jowl fat compartment (*7*, *blue dye*). Note that the tear trough, the lateral orbital thickening, and the area of the zygomatic arch did not stain. The dye did not migrate inferior to the nasolabial sulcus or medial to the labiomandibular sulcus. (*Right*) Cadaveric dissection of the left side of a face after the superficial (subcutaneous) fat compartments have been injected with colored dye: superficial nasolabial (*1*, *red dye*), medial cheek (*2*, *blue dye*), middle cheek (*3*, *red dye*), lateral cheek (*4*, *violet dye*), superficial superior temporal (*5*, *blue dye*), superficial inferior temporal (*6*, *red dye*), and jowl fat compartment (*7*, *blue dye*). *Asterisk* marks the platysma and identifies the compartments to lie superficial to it.

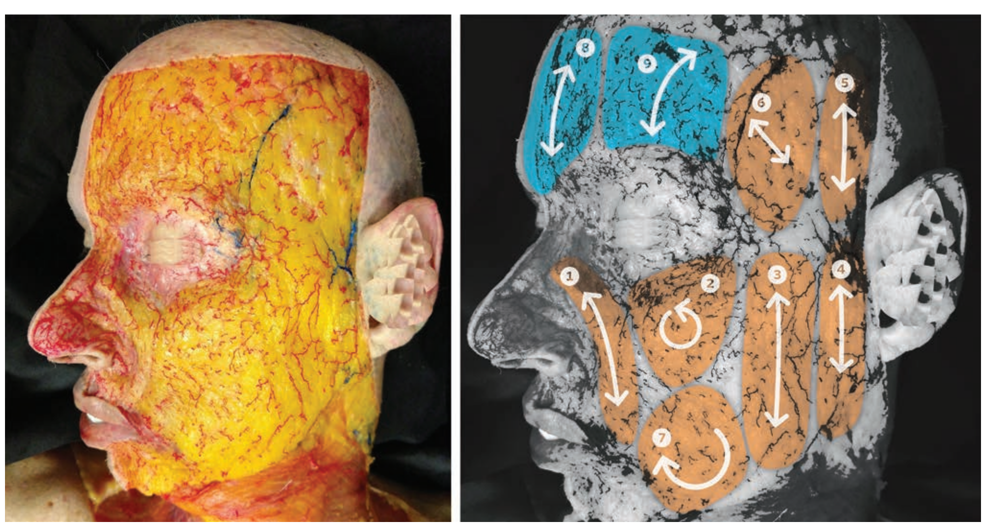

Fig. 4. (*Left*) Anatomical dissection of the subdermal arterial plexus after removal of the skin of a latex-injected body donor. Note the difference in orientation of the vasculature between the different compartments. (*Right*) Illustration of the superficial (subcutaneous) facial fat compartments. *Arrows* indicate the general vascular orientation of the subdermal plexus within each of the compartments: superficial nasolabial (*1*), medial cheek (*2*), middle cheek (*3*), lateral cheek (*4*), superficial superior temporal (*5*), superficial inferior temporal, (*6*) and jowl (*7*). The superficial central (*8*) and the superficial lateral (*9*) forehead compartments have also been visualized in this image.

Video 1. Supplemental Digital Content 1, shows manual movement of the superficial (subcutaneous) facial fat compartments to demonstrate mobility after dye has been injected and the skin has been removed, ***http://links.lww.com/PRS/C752***.

injected and the skin has been removed, ***http://links.lww.com/PRS/C752***.] When filled, the compartment had an oblique longitudinal axis that reached from the lateral side of the nose to the angle of the mouth and measured 70.5 ± 10.4 mm (Table 1). In none of the investigated samples did the contrast agent distribute superiorly into the tear trough or inferiorly into the nasolabial sulcus.

The amount of injected volume correlated significantly with the distance to the sella-nasion plane for the inferior aspect (r_p = 0.92, p = 0.003) but not with the most superior aspect (r_p = 0.40, p = 0.37) of the compartment. Advanced age (p < 0.001) but not increased body mass index (p = 0.26) had a significant influence when using adjusted regression models.

Superficial Medial Cheek Compartment

The superficial (subcutaneous) medial cheek fat compartment (also called the malar fat pad) had the shape of an upside-down triangle, with the upper horizontal limb of the triangle being located at the level of the inferior orbital rim (Table 1 and Figs. 1, 3, and 4) (**see Video, Supplemental Digital Content 1**, ***http://links.lww.com/PRS/C752***). The mean vertical and horizontal size of the compartment was 41.5 ± 10.4 mm and 39.7 ± 10 mm, respectively, with a mean injected volume of 8.24 ± 3.56 cc. No significant correlation was observed between the amount of injected volume and the displacement of the inferior or superior aspect of this compartment (r_p = 0.20, p = 0.75 and r_p = −0.38, p = 0.53). Adjusted models revealed that age did not significantly influence this relationship (p = 0.50), whereas body mass index did (p = 0.027).

Superficial Middle Cheek Compartment

The superficial (subcutaneous) middle cheek fat compartment had a rectangular shape and was located between the zygomatic arch and the mandible and lateral to the lateral canthus (Table 1 and Figs. 1 through 4) (**see Video, Supplemental Digital Content 1**, ***http://links.lww.com/PRS/C752***). The mean injected volume was 11.4 ± 6.6 cc, with a mean vertical and horizontal size of 63.4 ± 20.7 mm and 24.7 ± 5.0 mm, respectively. The amount of injected volume revealed a higher correlation for the most inferior aspect (r_p = 0.70, p = 0.05) compared with the most superior aspect (r_p = −0.03, p = 0.95) when related to the sella-nasion plane. Using adjusted models, age had no significant influence (p = 0.96), but increased body mass index did have a significant influence (p = 0.002).

Superficial Lateral Cheek Compartment

The superficial (subcutaneous) lateral cheek fat compartment also had a rectangular shape and was located between the zygomatic arch and the mandible and between the superficial middle compartment and the auricle (vertical level of the tragus) (Table 1 and Figs. 1 through 4) (**see Video, Supplemental Digital**

Table 1. Vertical and Horizontal Measures between the Horizontal Nasion Level and the Midline/Lateral Canthus to the Most Medial and Lateral Aspect of Each of the Superficial (Subcutaneous) Facial Fat Compartments

Superficial (Subcutaneous) Compartments	Mean Vertical Distance to Inferior Aspect Point ± SD (mm)	Vertical Distance to Superior Aspect ± SD (mm)	Mean Horizontal Distance to Medial Aspect ± SD (mm)	Mean Horizontal Distance to Lateral Aspect ± SD (mm)
Medial cheek	60.9 ± 11.38	19.4 ± 7.04	Midline, 23.1 ± 11.40	Midline, 62.3 ± 5.52
Nasolabial	81.67 ± 18.79	16.44 ± 9.54	Midline, 10.46 ± 2.84	Midline, 47.79 ± 6.69
Jowl	105.46±14.68	66.1 ± 12.90	Midline, 44.82 ± 22.49)	Midline, 59.18 ± 11.82
Middle cheek	84.75 ± 24.72	21.33 ± 13.88	Lateral canthus, 0.8 ± 10.37	Lateral canthus, 24.74 ± 8.36
Lateral cheek	104.64 ± 33.88	22.99 ± 26.75	Lateral canthus, 9.41 ± 11.74	Lateral canthus, 34.6 ± 7.73
Inferior temporal	20.77 ± 4.14	19.38 ± 5.29	Lateral canthus, 1.98 ± 2.10	Lateral canthus, 22.27 ± 3.13
Superior temporal	15.39 ± 8.08	33.58 ± 20.87	Lateral canthus, 6.02 ± 5.91	Lateral canthus, 22.71 ± 4.45

Content 1, ***http://links.lww.com/PRS/C752***). The mean volume of injected material until complete filling was achieved was 14.6 ± 4.2 cc, with a mean vertical and horizontal extent of 81.7 ± 14.5 mm and 25.1 ± 8.7 mm, respectively.

No significant correlation was found between the amount of injected volume and the distance of the most inferior or superior aspect of the compartment from the sella-nasion plane ($r_p = 0.15$, $p = 0.75/r_p = -0.03$, $p = 0.95$). Adjusted models revealed no significant influence of age ($p = 0.96$) or body mass index ($p = 0.86$).

Superficial Superior and Inferior Temporal Compartments

When injecting material into the subcutaneous layer of the temple, no displacement inferior to the zygomatic arch was observed (Figs. 1, 3, *left*, and 4). (**See Video, Supplemental Digital Content 2**, showing manual movement of the superficial inferior temporal compartment to demonstrate its stability against the lateral orbital thickening and the inferior temporal septum, ***http://links.lww.com/PRS/C753***.) However, two different compartments were identified: a more superoposterior compartment and a more anterointerior compartment. The separating boundary between these two compartments showed similarities in location and orientation to the inferior temporal septum; the latter, however, is located in a deeper plane (Table 1).

The mean filling volume of the superficial (subcutaneous) superior temporal fat compartment was 8.11 ± 3.3 cc, with a mean vertical and horizontal extent of 49.0 ± 19.6 mm and 17.9 ± 5.1 mm, respectively. For the superficial (subcutaneous) inferior temporal fat compartment, the mean filling volume was 6.67 ± 2.9 cc, with a mean vertical and horizontal extent of 40.2 ± 6.1 mm and 19.6 ± 4.4 mm, respectively.

Video 2. Supplemental Digital Content 2 shows manual movement of the superficial inferior temporal compartment to demonstrate its stability against the lateral orbital thickening and the inferior temporal septum, ***http://links.lww.com/PRS/C753***.

No significant correlations were found between the superior or the inferior aspect of both the superior ($r_p = 0.54$, $p = 0.13/r_p = -0.32$, $p = 0.41$) and the inferior ($r_p = 0.67$, $p = 0.14/r_p = -0.52$, $p = 0.29$) subcutaneous temporal fat compartments. Again, adjusted models revealed no influence of age or body mass index on either the superior ($p = 0.33$ and $p = 0.19$) or the inferior superficial temporal fat compartment ($p = 0.09$ versus $p = 0.39$).

Jowl Compartment

The superficial (subcutaneous) jowl fat compartment was located inferior to the medial cheek fat compartment, lateral to the superficial nasolabial fat compartment, medial to the superficial middle cheek fat compartment, and superior to the level of the mandible (Figs. 1, 3, and 4). (**See Video, Supplemental Digital Content 1**, ***http://links.lww.com/PRS/C752***.) This compartment was also found to be superficial to the superficial musculoaponeurotic system (SMAS) and separated from the buccal space; the latter is regarded as a deep facial fat compartment. The mean injected volume of the jowl fat compartment was 17.3 ± 6.0 cc, with a mean vertical and horizontal extent of 39.4 ± 3.4 mm and 28.5 ± 12.2 mm, respectively (Table 1).

Both the most superior and inferior aspects of this compartment revealed a significant correlation between the distance to the sella-nasion plane and the amount of injected volume ($r_p = 0.90$, $p = 0.04$; and $r_p = 0.92$, $p = 0.03$, respectively). When including age and body mass index into the adjusted model, age significantly influenced the inferior displacement ($p < 0.001$), whereas body mass index did not.

DISCUSSION

The results of this study revealed seven bilateral distinct superficial (subcutaneous) facial fat compartments (when excluding the three subcutaneous compartments of the forehead): superficial nasolabial, superficial medial cheek, superficial middle cheek, superficial lateral cheek, jowl, and superficial superior temporal and superficial inferior temporal (Figs. 1 and 3). The compartments were shown to be separated from each other and not to cover the area of the tear trough, the lateral orbital thickening, or the zygomatic arch. It was also observed that the compartments did not extend inferior or medial to the nasolabial sulcus or medial to the labiomandibular sulcus. With upright computed tomographic scanning, the effects of gravity were simulated and significant positive correlations between the amount of injected material and the inferior displacement of the fat compartments were found: for the superficial nasolabial ($r_p = 0.92$, $p = 0.003$), middle cheek ($r_p = 0.70$, $p = 0.05$), and jowl ($r_p = 0.92$, $p = 0.03$) compartments, no significant correlations were found for the medial cheek ($r_p = 0.20$, $p = 0.75$), lateral cheek ($r_p = 0.15$, $p = 0.75$), or the two superficial temporal compartments [superior ($r_p = -0.32$, $p = 0.41$) and inferior ($r_p = -0.52$, $p = 0.29$)]. Increased age was shown to have a significant influence on the inferior displacement of the superficial nasolabial and jowl compartments ($p < 0.001$); these compartments are known to have a substantial influence on the appearance of the aging face.

One of the strengths of the present study is that we were able to visualize each of the superficial (subcutaneous) facial fat compartments on an individual basis and were able to calculate positional changes based on the various amounts of volume injected. Previous studies using magnetic resonance imaging did not apply contrast agent for the visualization of each subcutaneous facial fat compartment, and it can be assumed therefore that the results presented reflect a more regional approach: multiple or incomplete compartments were included to guide conclusions.[12–16,20] Our study provides the basis for a greater awareness and deeper understanding of the delicate underlying functional anatomy to help clinicians achieve the best aesthetic outcomes and long-lasting results.

Previous CT imaging studies[4,5] visualized the individual facial fat compartments, but the cephalic specimens used in those studies did not have an intact anatomy due to previously performed postmortem surgical procedures during anatomical simulation courses for neurosurgical and/or invasive ophthalmologic procedures. As these procedures lead to a disruption of the integrity of skin, SMAS and deeper structures of the forehead and temple the results presented need to be interpreted with caution as a potential bias could have been introduced.

Another strength of this study is that we performed the computed tomographic scanning of the cephalic specimen in the upright position and simulated the effects of gravity. Previous magnetic resonance imaging studies[12–16,20,21] were not able to conduct studies in the upright position because of a size limitation of the headrest; the scanning procedures were performed in the supine or prone setting. This potentially creates a bias in the interpretation of the results, as it has been shown that the fat compartments of the face shift their position depending on the position of the head.[22]

The results of this study reveal that the superficial (subcutaneous) fat compartments behave differently on the injection of filling material. Whereas the inferior aspect of the nasolabial, middle cheek, and jowl compartments descended on filling, this effect was not observed for the medial or lateral cheek compartment or either of the superficial temporal compartments. These results correlate with the clinical appearance of the aging face where a prominent nasolabial sulcus, a prominent labiomandibular sulcus, and an increased jowl deformity can be identified, but not descent of the medial (malar fat pad) and lateral cheek or the superficial temporal fat compartments. An explanation for this behavior could be that the boundaries of the medial cheek compartment are more stable than those of other compartments; the superior boundary is closely related to the orbicularis retaining ligament, whereas the inferior boundary is related to the zygomaticus major muscle. An explanation for the stability of the lateral cheek compartment could be that it lies on top of the midfacial SMAS—known to be strongly adherent to the underlying parotideomasseteric fascia in this region—and inferior displacement could be limited by this anatomical arrangement.

The ligamentous arrangement of the temple could explain the stability of the superficial temporal compartments; the boundaries of these compartments can be related to the lateral orbital thickening, the inferior temporal septum, and the zygomaticocutaneous adhesions at the level of the zygomatic arch. It must be noted, however, that the volumes of injected fillers used in this study exceed those volumes typically used during routine facial rejuvenation procedures. The large amounts injected were specifically chosen for two reasons: (1) to achieve complete filling of the respective compartments, to describe the precise anatomical location and extent of each individual compartment (Table 1) and to prove that boundaries truly exist, although they are not visible during surgical procedures or anatomical dissections; and (2) to simulate the effects of aging in a "fast-forward model" by testing the stability of suspensory structures (ligaments, muscles, or compartment boundaries). It is believed that these large volumes truly test whether such support is present. The process of aging relies on the stability of this support, and clinical observations show that, with advanced age, this support gradually diminishes and an aged facial appearance results. The present study accelerates this process by the large volumes implanted and measures the inferior displacement of compartment content and performs crude and adjusted models to identify the contributing factors.

Contrary to current understanding, we were not able to detect the previously reported connection between the superficial temporal compartments and the middle and lateral subcutaneous compartments; the latter are located in the midface, spanning the zygomatic arch (Figs. 1 and 3). A possible explanation could be that the dye used in the present study was more viscous compared with the methylene blue from previous studies.[2] This would be in line with two previous reports by Pilsl and Anderhuber,[8,9] where the authors used viscous Tandler gelatin[23] to stain the subcutaneous fat compartment and identified the zygomatic arch as a boundary between the temporal and the midfacial compartments. In addition, our study used computed tomographic scanning and magnetic resonance imaging to identify compartments and their boundaries after injection; computed tomographic scanning and magnetic resonance imaging do not disrupt tissue integrity or the injected contrast agent and might therefore strengthen the hypothesis that the zygomatic arch functions as a boundary between the two superficial temporal compartments and the midfacial compartments.

Previous studies provided evidence for the age-related fat distribution from superficial to visceral fat[24–26] and indicated a loss of total subcutaneous fat mass. This loss of subcutaneous fat is regarded as one of the reasons for the appearance of the aging face and can be treated by soft-tissue filler augmentation.[2] Our study was able to detect a significant influence of age both on the superficial nasolabial and on the jowl compartments; this is in keeping with the clinical appearance of an aged face in which a deeper nasolabial sulcus and the jowl deformity can be observed. Assuming "empty" compartments because of advanced age, but with intact boundaries, it would be plausible that "refilling" of the compartments with contrast agent would lead to an inferior displacement of the injected material; this would be indicated by an increased distance of the inferior aspect of the compartment from a static reference point.

In a clinical setting, care must be taken when injecting volumizing material into the subcutaneous plane. Targeting specific superficial fat compartments, such as the superficial nasolabial fat compartment, can result in an effect opposite to that desired: instead of reducing the nasolabial crease depth by the implantation of soft-tissue filler, a worsening of its appearance and a deepening of the crease can be noted when volume is injected into this compartment (cranial to the nasolabial crease). Based on the results of this study, this clinical effect can be confirmed; injections of filler into the superficial nasolabial compartment are positively correlated to an inferior displacement of this compartment. On the contrary, injections of soft-tissue filler into the superficial temporal compartments or the superficial medial cheek compartment (also called the malar fat pad) have been associated not with descent but with an increase in the local volume and an increase in the soft-tissue projection capable of inducing a lifting effect in the middle and/or lower face. The results of the present study can confirm this clinical finding; no correlation was identified between the amount of filler injected and any inferior displacement of these respective compartments.

CONCLUSIONS

This study confirmed the presence of distinct subcutaneous facial fat compartments and provided evidence that such compartments behave differently when soft-tissue fillers are applied within: injection of volumizing material leads to an inferior displacement of the superficial nasolabial, middle cheek, and jowl compartments. Injection into the medial cheek, lateral cheek, and superficial temporal compartments leads to an increase in volume without inferior displacement (i.e., an increase in local projection).

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ACKNOWLEDGMENTS

The imaging part of this study received funding from Q-Med AB, Sweden (grant number 15092016). The authors would like to thank Markus Schlager for support in the imaging parts of this study and Robert H. Gotkin, M.D., for guidance during the writing process.

REFERENCES

1. American Society of Plastic Surgeons. 2016 plastic surgery statistics. Available at: https://d2wirczt3b6wjmn.cloudfront.net/News/Statistics/2016/2016-plastic-surgery-statistics-report.pdf. Accessed January 1, 2017.

2. Rohrich RJ, Pessa JE. The fat compartments of the face: Anatomy and clinical implications for cosmetic surgery. *Plast Reconstr Surg.* 2007;119:2219–2227; discussion 2228–2231.
3. Cotofana S, Schenck TL, Trevidic P, et al. Midface: Clinical anatomy and regional approaches with injectable fillers. *Plast Reconstr Surg.* 2015;136(Suppl):219S–234S.
4. Gierloff M, Stöhring C, Buder T, Gassling V, Açil Y, Wiltfang J. Aging changes of the midfacial fat compartments: A computed tomographic study. *Plast Reconstr Surg.* 2012;129:263–273.
5. Gierloff M, Stöhring C, Buder T, Wiltfang J. The subcutaneous fat compartments in relation to aesthetically important facial folds and rhytides. *J Plast Reconstr Aesthet Surg.* 2012;65:1292–1297.
6. Pessa JE. SMAS fusion zones determine the subfascial and subcutaneous anatomy of the human face: Fascial spaces, fat compartments, and models of facial aging. *Aesthet Surg J.* 2016;36:515–526.
7. Pezeshk RA, Stark RY, Small KH, Unger JG, Rohrich RJ. Role of autologous fat transfer to the superficial fat compartments for perioral rejuvenation. *Plast Reconstr Surg.* 2015;136:301e–309e.
8. Pilsl U, Anderhuber F. The septum subcutaneum parotideomassetericum. *Dermatol Surg.* 2010;36:2005–2008.
9. Pilsl U, Anderhuber F. The chin and adjacent fat compartments. *Dermatol Surg.* 2010;36:214–218.
10. Mertens A, Foyatier JL, Mojallal A. Quantitative analysis of midface fat compartments mass with ageing and body mass index, anatomical study. *Ann Chir Plast Esthet.* 2016;61:798–805.
11. Mendelson BC, Jacobson SR. Surgical anatomy of the midcheek: Facial layers, spaces, and the midcheek segments. *Clin Plast Surg.* 2008;35:395–404; discussion 393.
12. Gosain AK, Klein MH, Sudhakar PV, Prost RW. A volumetric analysis of soft-tissue changes in the aging midface using high-resolution MRI: Implications for facial rejuvenation. *Plast Reconstr Surg.* 2005;115:1143–1152; discussion 1153–1155.
13. Le Louarn C, Buthiau D, Buis J. Structural aging: The facial recurve concept. *Aesthetic Plast Surg.* 2007;31:213–218.
14. Wysong A, Kim D, Joseph T, MacFarlane DF, Tang JY, Gladstone HB. Quantifying soft tissue loss in the aging male face using magnetic resonance imaging. *Dermatol Surg.* 2014;40:786–793.
15. Wysong A, Joseph T, Kim D, Tang JY, Gladstone HB. Quantifying soft tissue loss in facial aging: A study in women using magnetic resonance imaging. *Dermatol Surg.* 2013;39:1895–1902.
16. Corey CL, Popelka GR, Barrera JE, Most SP. An analysis of malar fat volume in two age groups: Implications for craniofacial surgery. *Craniomaxillofac Trauma Reconstr.* 2012;5:231–234.
17. Rohrich RJ, Pessa JE. The retaining system of the face: Histologic evaluation of the septal boundaries of the subcutaneous fat compartments. *Plast Reconstr Surg.* 2008;121:1804–1809.
18. Schaverien MV, Pessa JE, Rohrich RJ. Vascularized membranes determine the anatomical boundaries of the subcutaneous fat compartments. *Plast Reconstr Surg.* 2009;123:695–700.
19. Wan D, Amirlak B, Rohrich R, Davis K. The clinical importance of the fat compartments in midfacial aging. *Plast Reconstr Surg Glob Open* 2013;1:e92.
20. Gosain AK, Amarante MT, Hyde JS, Yousif NJ. A dynamic analysis of changes in the nasolabial fold using magnetic resonance imaging: Implications for facial rejuvenation and facial animation surgery. *Plast Reconstr Surg.* 1996;98:622–636.
21. Foissac R, Camuzard O, Piereschi S, et al. High-resolution magnetic resonance imaging of aging upper face fat compartments. *Plast Reconstr Surg.* 2017;139:829–837.
22. Mally P, Czyz CN, Wulc AE. The role of gravity in periorbital and midfacial aging. *Aesthet Surg J.* 2014;34:809–822.
23. Mulisch M, Welsch U. *Romeis: Mikroskopische Technik.* Heidelberg: Spektrum; 2010.
24. Sepe A, Tchkonia T, Thomou T, Zamboni M, Kirkland JL. Aging and regional differences in fat cell progenitors: A mini-review. *Gerontology* 2011;57:66–75.
25. Palmer AK, Kirkland JL. Aging and adipose tissue: Potential interventions for diabetes and regenerative medicine. *Exp Gerontol.* 2016;86:97–105.
26. Lakowa N, Trieu N, Flehmig G, et al. Telomere length differences between subcutaneous and visceral adipose tissue in humans. *Biochem Biophys Res Commun.* 2015;457:426–432.