Over the past three decades, anatomical advances by means of cadaver dissection and medical imaging have highlighted volume loss as a principal cause of facial aging. Initial volumization techniques emphasized dermal and superficial subcutaneous injections; however, recently, there has been a paradigm shift in treating the aging face with deep tissue correction. Because of the rapid expansion of minimally invasive cosmetic facial interventions, it is critical that aesthetic surgeons maintain proficiency in these approaches to optimize patient outcomes in a longitudinal and comprehensive manner. It is equally important to educate noncore medical specialists engaging in nonsurgical cosmetic rejuvenation about the limitations and dangers of these approaches and when such treatments may not be constructive for a given patient. This article, anatomical changes seen with aging are illustrated, appropriate techniques for facial volumization are described in the setting of correct filler selection, and potential complications are addressed. (Plast. Reconstr. Surg. 137: 872e, 2016.)

TEMPORARY FILLERS AND THEIR CHARACTERISTICS

The two principal categories of temporary fillers approved by the U.S. Food and Drug Administration for facial rejuvenation are hyaluronic acid and calcium hydroxylapatite. The semipermanent filler polymethylmethacrylate, the biostimulator poly-L-lactic acid, and autologous fat represent distinct alternatives with unique biological properties and injection techniques, and thus are discussed here.1–17 Hyaluronic acid fillers were introduced for intra-dermal injection in the United States in 2003 and have since become the predominant fillers for soft-tissue augmentation.18–26 Current U.S. Food and Drug Administration–approved hyaluronic acid fillers are produced by means of nonanimal stabilized hyaluronic acid technology; however, Disclosure: Dr. Percec is a paid consultant for Galderma. All interaction with Galderma occurred after the submission of this CME article. Consultation has regarded products not included in this article. All products were used from stock supply of the Division of Plastic Surgery at the University of Pennsylvania with the exception of six syringes of Restylane Silk supplied by Galderma prior to its commercial release in the United States. Drs. Wilson, Taglienti, Chang, and Low have no financial disclosures to report.

Related Video content is available for this article. The videos can be found under the “Related Videos” section of the full-text article, or, for Ovid users, using the URL citations published in the article.
novel fillers produced by means of alternate technologies such as the Emervel (Galderma, Lausanne, Switzerland) line, manufactured by means of optimal balance technology, will likely enter the market. Calcium hydroxylapatite (Radiesse; Galderma) is another temporary filler with properties similar to those of hyaluronic acids. In this article, we focus on hyaluronic acid– and calcium hydroxylapatite–based soft-tissue facial augmentation.

Temporary soft-tissue fillers are classified by their composition and rheologic properties, specifically, elasticity ($G'$), viscosity ($n^*$), hydrophilicity, particle size, particle concentration, and crosslinking (Table 1). $G'$ describes a material’s ability to resist compression, whereas $n^*$ refers to a material’s ability to resist shearing forces. Hydrophilicity is the product’s capacity to attract water and expand. Particle size, as determined by the polymerization of the glycosaminoglycan chains and straining techniques, contributes to the filler’s overall “lifting and filling power.” Increased particle concentration and crosslinking strengthens hyaluronic acid durability by means of resistance to enzymatic degradation. These properties differ between fillers, with each product being characterized by a unique set of rheologic features. Consequently, these variables must be judiciously taken into consideration relative to a patient’s specific anatomy and soft-tissue characteristics during facial volumization (Figs. 1 and 2).

**TEMPORARY FILLER INJECTION TECHNIQUES**

Multiple injection techniques exist for soft-tissue volumization (Fig. 3). The proper technique is dependent on injector preference and training, product selected, and anatomical region addressed. For superficial and dermal filling, injectors most often use a threading approach, or less often, fanning or cross-hatching techniques in a retrograde or anterograde manner. Deep volumization techniques in the subcutaneous and periosteal planes more frequently include towering, layering, and depot injections. Irrespective of injection technique and tissue depth, aspiration before product injection is recommended to avoid intravascular injection. Product blending with sterile saline, lidocaine, or lidocaine with epinephrine may be chosen in specific anatomical zones and product combinations to tailor rheologic properties.

Injectors have recently begun using blunt cannulae in place of sharp needles. This technique may lead to increased patient comfort, a reduction in edema and ecchymoses, and a more

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**Table 1. Commonly Used Hyaluronic Acid and Calcium Hydroxylapatite Fillers Currently Approved by the U.S. Food and Drug Administration**

<table>
<thead>
<tr>
<th>Name</th>
<th>Elasticity ($G'$)</th>
<th>Viscosity ($n^*$)</th>
<th>HA Concentration (mg/ml)</th>
<th>Relative Injection Depth</th>
<th>Lidocaine</th>
<th>FDA Approval Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restylane†</td>
<td>514</td>
<td>119,180</td>
<td>20</td>
<td>Superficial-medium</td>
<td>No</td>
<td>2003</td>
</tr>
<tr>
<td>Restylane-L†</td>
<td>565</td>
<td>131,310</td>
<td>20</td>
<td>Superficial-medium</td>
<td>Yes</td>
<td>2010</td>
</tr>
<tr>
<td>Restylane Silk†</td>
<td>459</td>
<td>107</td>
<td>20</td>
<td>Superficial-medium</td>
<td>Yes</td>
<td>2014</td>
</tr>
<tr>
<td>Restylane Lyft†</td>
<td>549</td>
<td>127,090</td>
<td>20</td>
<td>Medium-deep</td>
<td>Yes</td>
<td>2010</td>
</tr>
<tr>
<td>Belotero Balance‡</td>
<td>30</td>
<td>9217</td>
<td>22.5</td>
<td>Superficial</td>
<td>No</td>
<td>2011</td>
</tr>
<tr>
<td>Radiesse‡</td>
<td>1407</td>
<td>349,830</td>
<td>NA</td>
<td>Medium-deep</td>
<td>No</td>
<td>2006</td>
</tr>
<tr>
<td>Radiesse (+)‡</td>
<td>~1180</td>
<td>~3,010,000</td>
<td>NA</td>
<td>Medium-deep</td>
<td>Yes</td>
<td>2015</td>
</tr>
<tr>
<td>Juvederm Ultra XCS§</td>
<td>111</td>
<td>27,034</td>
<td>24</td>
<td>Superficial-medium</td>
<td>Yes</td>
<td>2006</td>
</tr>
<tr>
<td>Juvederm Ultra Plus XCS§</td>
<td>136</td>
<td>32,152</td>
<td>24</td>
<td>Medium-deep</td>
<td>Yes</td>
<td>2010</td>
</tr>
<tr>
<td>Juvederm Voluma XCS§</td>
<td>274</td>
<td>92,902</td>
<td>20</td>
<td>Medium-deep</td>
<td>Yes</td>
<td>2013</td>
</tr>
<tr>
<td>Prevelle Silk‖</td>
<td>230–260</td>
<td>NA</td>
<td>5.5</td>
<td>Superficial</td>
<td>Yes</td>
<td>2008</td>
</tr>
</tbody>
</table>

*HA, hyaluronic acid; FDA, U.S. Food and Drug Administration; NA, not available.

†Merz Aesthetics, Lausanne, Switzerland.
§Allergan, Inc., Irvine, Calif.
‖Mentor Corp., Santa Barbara, Calif.

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predictable recovery. (See Video, Supplemental Digital Content 1, which displays how the nasojugal groove is treated with a blunt cannula technique, available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B692.) Cannulae may be preferable to needles in regions prone to bruising or at higher risk for potential intravascular...
injection, or when the patient cannot tolerate a standard recovery period. Despite these benefits, many injectors still prefer needle injection techniques, citing additional training for using cannulae, increased cost, difficulty threading the cannulae, and impaired ability to treat all areas effectively. It remains to be determined whether cannula-based techniques will expand and potentially replace needle-based approaches in the United States.

**CHARACTERIZING AND TREATING FACIAL VOLUME LOSS**

For consistent and effective facial analysis, it is helpful to consider the topography of the face as being divided into thirds (i.e., the upper face, midface, and lower face). Each region undergoes characteristic volume atrophy or hypertrophy that is combined with increased overall facial strain and an overall decrease in soft-tissue integrity (Fig. 4). Specific changes vary between individuals depending on the patient’s underlying bony structure, weight, and soft-tissue quality. In this article, the anatomical changes associated with aging are described for each third of the face, from the top down and deep to superficial, to simulate clinical scenarios for facial assessment and structural volumization design. For each region, volume correction will address bony and soft-tissue atrophy. Rhytide-specific and superficial (deep-dermal) augmentation is highlighted last as a finishing effect, after structural volumization. Patient assessment
for each facial region is described, as is the rationale for filler selection and injection techniques. Examples of total facial volumization are provided (Figs. 5 and 6).

**METHODOLOGY**

Patients that were appropriate medical candidates for filler injections were selected for characteristic age-related facial volume loss. Patients were instructed to avoid aspirin and nonsteroidal antiinflammatory drugs for 1 week before injection. Patients’ faces were washed of makeup, and three-dimensional images were taken with the Canfield Vectra System (Canfield Scientific, Fairfield, N.J.) and by means of standard digital photography. LMX 4% topical anesthetic cream (Ferndale Laboratories, Inc., Ferndale, Mich.) was applied to areas to be injected for 15 minutes. The LMX cream was removed and the patients’ faces were cleansed first with isopropyl alcohol (70%) and then with chlorhexidine gluconate 4% solution immediately before injection. Injections were conducted as described in the figure legends and videos. After the procedure, injection sites were treated with cold packs for 10 minutes followed by photography. Repeated images of patients were obtained 2 weeks after injection.

**Upper Face: Temples, Brows, and Superior Periorbital Area**

The youthful upper face is characterized by a subtle convexity of the temple, forehead, and lateral brow and fullness of the upper eyelids.\(^1^6\) During aging, there is incremental volume loss in these regions. Although the severity of volume loss varies between patients, the ensuing temporal narrowing and periorbital hollowing remain underrecognized and undertreated.\(^3^0,4^7\) Temporal narrowing may result in decreased lateral brow support, with consequent lateral brow ptosis and pseudodermatochalasis of the upper lid. These changes give an overall tired, aged appearance to the upper face, and often represent the first signs of facial aging in the fourth decade of life (Fig. 7).

Upper facial volume loss is secondary to both bony and deep soft-tissue changes. Specifically, there is remodeling of periorbital bone in the superomedial and inferolateral directions, resulting in an altered and vertically lengthened orbital aperture, and an increased susceptibility to lower lid hollowing and contour deformities.\(^3^7,4^1,4^2,4^8,4^9\) Soft-tissue atrophy of the upper face occurs in defined sites of adipose deposition. At the temple, the deep temporal fat pad and the temporal extension of the buccal fat pad atrophy. The forehead and lateral brow undergo thinning of the subcutaneous plane, and the upper lids typically

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**Fig. 4.** During facial analysis, the topography of the face is often divided into the upper face, midface, and lower face. For volumization assessment, the upper face is composed of the temples, brows, and periorbital areas, and occasionally the forehead. The midface is composed of the malar, submalar, and preauricular regions; the nasolabial folds; and the nose. The lower face is composed of the posterior, middle, and anterior jawline; the perioral area; and the lips. Each region contains anatomically compartmentalized fat pads (labeled), which undergo characteristic and often predictable volume changes.
lose volume in the retro-orbicularis oculi fat pad and the medial and lateral fat pads.

The correction of upper facial volume loss at the temple and the upper brow requires fillers with appropriate rheologic properties for deep volumization, specifically an elevated $G'$ and $n^*$, whereas fillers for volumization of the upper lid, forehead, and crow’s feet should possess lower $G'$ and $n^*$ profiles (Figs. 1 and 2).50,51 Currently, there are no U.S. Food and Drug Administration–approved fillers for treatment of these regions and thus fillers are used in off-label fashion for these indications. Restylane Lyft, Radiesse, and Juvederm VolumaXC and Juvederm Ultra Plus XC are suitable for the deep treatment of the temple and upper brow.50 The increased $G'$ of these products...
allows for precise placement on the periosteum, providing structural and lifting support to overlying tissues with a low likelihood of displacement. Restylane-L, Restylane-Silk, Belotero Balance, and Juvederm Ultra XC are suitable fillers for superficial treatment of the temple, upper brow, and eyelid. Selection is based on injector experience, desired product duration, and cost.

We have come to appreciate that the anatomical order of contouring influences the ultimate outcome of facial volumization. Augmentation of the temple alone may provide lateral brow support and therefore should be addressed before moving more caudally. When injecting the temple, careful attention must be paid to the location of temporal vessels and superficial veins (Fig. 8). Our preferred injection plane is supraperiosteal. Using a 27-gauge needle and the perpendicular depot technique, the needle is advanced to the periosteum. Aspiration is performed and the product is deposited. Serial injections are associated with an increased risk of ecchymosis and injury to critical structures, but may provide more discriminative results. (See Video, Supplemental Digital Content 2, which displays potential techniques for upper facial volumization, with a focus on the temple and the brow, available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B693.) This approach, in our opinion, provides the longest lasting and
most natural correction, although other injectors have reported equally successful results with more superficial injections. Superficial correction in the subgaleal plane is an alternative for those wishing to minimize the cost and amount of product injected.

After volumization of the temple, attention is turned to the brow and upper lid. Here, volume loss occurs in both bone and more superficial tissues, including subcutaneous fat and the retro-orbicularis oculi fat pad. To correct this deficit, our preference is to initially inject product directly onto periosteum approximately 1 cm superior to the upper lateral orbital rim or just above the superior lateral brow hairline. Medial brow injection is rarely necessary secondary to infrequent medial brow ptosis. If additional volumization is warranted, a modest amount of product is also

**Fig. 8.** A complete understanding of facial arterial and venous anatomy is essential for the injector. In addition to the path of the vasculature, depth must also be taken into account. Avoidance of arterial injection or compromise will prevent the rare but devastating complications of soft-tissue volumization. In the upper face, the injector must take care to avoid the branch superficial temporal artery and vein during injection of the temples and the supratrochlear and supraorbital arteries during injection of the glabella. The supratrochlear and supraorbital arteries run deep below the corrugator and progress superficially as they course superiorly. The branches of the temporal artery run superficially and traverse the temporal fossa in the superficial temporal fascia. These vessels are palpable and likewise easily avoided. In the midface, care must be taken to avoid the transverse facial artery and its branches, the angular artery, and the infraorbital artery and its associated foramen medially. The transverse facial artery runs superficially in the malar region and branches into superficial plexus. The infraorbital foramen is located approximately 0.6 to 1 cm below the infraorbital rim in the axis with the midpupillary line. In the lower face, the facial artery and its branches must be avoided. The facial artery runs approximately 1 cm anterior to the masseter and directly over the periosteum and remains deep as it traverses superomedially. When injecting the chin area, the mental artery and nerve should be avoided. The mental foramen is located directly caudal to the second premolar tooth.

**Video 2.** Supplemental Digital Content 2, which displays potential techniques for upper facial volumization, with a focus on the temple and the brow, is available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B693.
added to the subcutaneous fat of the brow and/or retro-orbicularis oculi fat pad (see Video, Supplemental Digital Content 2, http://links.lww.com/PRS/B693). Notably, some authors advocate direct suborbicularis injection in the upper lid. Although direct injection in this plane may provide an effective way of correcting upper lid hollowing, given the proximity to the globe and its vasculature, this approach poses additional risks and should be limited to expert injectors.

Midface: Inferior Periorbital Area, Malars, Maxilla, and Nasolabial Fold

Midface deflation manifests as loss of malar projection and nasal support, with accentuation of the lower eyelid contour. Photographic, radiographic, and cadaver studies confirm age-related bony loss of the orbit and maxilla, and a posterior rotation of the maxilla leading to a decrease in the maxillary angle and widening of the pyriform aperture. These changes are accompanied by atrophy of inferior lid fat compartments, the suborbicularis oculi fat, and laxity of the orbicularis oculi and associated orbitomalar ligament. The resulting effect on the lower periorbital region is a decrease in the lateral canthal angle, descent of the lateral canthal tendon, loss of lower eyelid tone and hollowing, and the characteristic tear trough deformity (Fig. 9). The deflated midface is marked by prominent transitions between cheek fat pads, flattening of the malar prominence, increased nasolabial fold depth, lengthening of the cutaneous upper lip, and overall loss of lip volume. Consequently, accurate assessment of midface volume loss is the single most important factor for appropriate correction of facial volume, as precise restoration can rejuvenate both the upper and lower face.

We advocate correction of the malars before tear trough, lower lid, and nasolabial fold injection. This holds true for the majority of patients, in whom malar volume loss contributes to nasolabial

Fig. 9. Lower lid contour is affected by anatomical changes in intrinsic lower lid tissues including atrophy of inferior lid fat compartments, atrophy of the suborbicularis oculi fat, laxity of the orbicularis oculi and associated orbitomalar ligament and, importantly, volume atrophy of the malar region. This constellation of changes is often manifested as a double convexity with prolapsed orbital fat as a superior convexity that is separated from the inferior convexity of the descending malar mound by the skeletonized orbital rim. The medial soft-tissue atrophy of the orbital rim, characterized as the tear trough deformity, or nasojugal groove, extends inferolaterally to accentuate the malar mound and is an easily recognized site of volume atrophy. Less commonly appreciated, however, is the volume atrophy of the lateral orbital rim, which frequently requires augmentation for a cohesive natural result. This image demonstrates the periocular changes that occur with aging. (Left) Patient at age 21 years; (right) patient at age 57 years.
fold severity and the tear trough. The exception, in our opinion, is the rare patient who presents early in the aging process with isolated, fine nasolabial fold rhytides or nasojugal grooves and no discernible malar volume loss. With the exception of Juvederm Voluma XC, no fillers are currently U.S. Food and Drug Administration approved for malar enhancement.59,60 Nevertheless, Restylane Lyft, Radiesse, and Juvederm Ultra Plus XC are suitable fillers for deep treatment of the malars, given their elevated G’ and n* (Figs. 1 and 2). Malar injection should be performed in the supraperiosteal or fat pad plane using a depot, stacking, or tower technique, after aspiration. (See Video, Supplemental Digital Content 3, which shows a midface volumization with attention to the malar region, available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B694.) The location of the infraorbital foramen should be appreciated and avoided when treating the anteromedial malar compartment. The quantity of filler used is dependent on the degree of atrophy and product used, typically an average of 1 to 2 cc per side. Careful attention should be paid to restorative effects on the lower lid, nasolabial fold, nasal base, and upper lip during malar augmentation.

If, following malar augmentation, direct correction of the medial or lateral orbital rim is warranted, we advocate conservative linear threading in the supraperiosteal plane with meticulous preinjection aspiration to avoid intravascular injection and catastrophic retinal artery occlusion.60 It should be noted that other injectors have reported equally successful results with alternative techniques. The use of cannulae to avoid vascular injury and minimize bruising in this area is ideal. (See Video, Supplemental Digital Content 1, http://links.lww.com/PRS/B692. See Video, Supplemental Digital Content 4, which displays a needle-based, sharp technique of nasojugal groove treatment, available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B695.) Treatment of the crow’s feet as an adjunct to periorbital volumization may be conducted in the deep dermal plane using a threading or crosshatching technique. We prefer Restylane-L, Restylane Silk, or Belotero Balance blended with 1% lidocaine and 1:100,000 epinephrine for volumization of the skeletonized orbital rim and crow’s feet and recommend avoidance of hydrophilic products or those with high G’ and n* profiles in this area. This approach encourages minimal contour deformities, edema, and ecchymoses.

Deep volumization at the level of the nasal sill can provide support to the aging nasal tip; a natural correction of the upper nasolabial fold; and, often, a minor lift to the upper lip. Much like the temple and malar regions, we advocate that enhancement at this level requires periosteal placement of high G’, large-particle fillers. In this approach, the needle is placed at the lateralmost point of the alar base; advanced down to the periosteum, superior to the dentition and deep to the oral mucosa; and, after aspiration, a single depot of filler (approximately 0.3 to 0.5 cc per side) is placed. Injection in this plane should provide a natural restoration of age-related maxillary deficits and avoid the major facial vessels that course in a more superficial plane.

Video 3. Supplemental Digital Content 3, which shows a midface volumization with attention to the malar region, is available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B694.

Video 4. Supplemental Digital Content 4, which displays a needle-based, sharp technique of nasojugal groove treatment, is available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B695.
Correction of the nasolabial fold merits specific mention. Although this site was the first to be approved by the U.S. Food and Drug Administration for treatment and continues to be the only approved site of injection for many fillers in the United States, we maintain that the nasolabial fold is overtreated and misunderstood. Unlike the remaining face, the nasolabial fold hypertrophies with age. Fillers in this region, in our opinion, should be used to soften a prominent fold and not to volumize. Because the nasolabial fold is most often the patient’s chief complaint, it is essential for injectors to educate patients that correction of malar volume will more naturally and effectively treat the aging face. We therefore advocate that deficient malar volume should be corrected before the nasolabial fold. Once the malar region has been augmented, the residual nasolabial fold can be softened conservatively (Fig. 10). (See Video, Supplemental Digital Content 5, which displays a technique of nasolabial fold filling, available in the “Related Videos” section of the full-text article on www.PRSJournal.com or at http://links.lww.com/PRS/B696.)

Lower Face: Jawline, Perioral Area, and Lips

The general widening and loss of integrity of the lower face can be perceived as a relative increase in volume at the jowls with a concomitant decrease in jawline strength and perioral and lip volume. The jowls, characterized anatomically as three fat pads separated by an intervening septum, become more prominent with age secondary to deflation of the superficial fat exposing deeper fat pads, descent of deep fat pads, and increased septal laxity. These changes are exacerbated by volume loss in the region anterior to the jowls, the prejowl sulcus, and volume loss posterior to the masseter in the posterior jawline and inferior preauricular region.\textsuperscript{45,61–64} The perioral area undergoes both superficial and deep atrophy. This is manifested as a lengthening and flattening of the upper lip complex, and a loss of vermillion and vermillion border volume with formation of vertical perioral rhytides (Fig. 11). There is a concomitant downturning of the oral commissure.