Periocular Fillers and Related Anatomy

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PRACTICE POINTS

- When performing periocular dermal injections, physicians should understand the complicated anatomy surrounding the eyes and related changes with upper face aging.
- The different rheological properties of facial fillers impact product selection for various areas of the upper face.
- Physicians should be aware of the anatomical danger zones to avoid intravascular embolization.

Aging of the periocular area involves changes of the skin, muscle, fat, and bones. Facial fillers can be helpful in minimizing these changes by restoring youthful fullness to periocular areas that have undergone volume loss or loss of support. Physicians should understand the complicated anatomy surrounding the eyes, both to understand the aging process and to minimize treatment complications.

Cutis. 2016;98:330-335.

Rejuvenation of the periocular area is in high demand among patients who want to look and feel their best. Physicians should understand the complicated anatomy surrounding the eyes before attempting to inject this area with facial fillers, both to understand the aging process and to minimize treatment complications.

Basic Oculoplastic and Orbital Anatomy

The injector should understand the anatomy of the periocular muscles, the orbital osteology, and the secretory and lacrimal system, in addition to the fat, ligaments, and vascular anatomy in this area.[1]

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The eyes are surrounded by fat compartments that provide glide planes for the motion of the eyelids and globe. There are 2 upper eyelid fat-pads—nasal and central [preaponeurotic])—in the upper lid, leaving room for the lacrimal gland laterally. There are 3 fat compartments—nasal, central, and lateral—in the lower eyelid. The nasal and central compartments are separated by the inferior oblique muscle, which elevates and extorts the eye. The orbital septum holds the fat-pads in place in the orbit. The brow fat-pad is the retro-orbicularis oculi fat-pad (ROOF). There are fat compartments that lie in the subcutaneous space along the entire forehead and in the temple. The suborbicularis oculi fat-pad (SOOF) lies over the malar eminence. Superficial and deep submuscular fat compartments of the face have been described.[2] Deep fat compartments also have been examined on computed tomography.[3]

Orbital circulation comes from the internal carotid artery and anastomoses with the supply from the external carotid artery to supply the orbit. The first branch off of the carotid artery is the ophthalmic artery, and the first branch off of the ophthalmic artery is the central retinal artery that enters the optic nerve sheath 1 cm behind the globe to supply the retina. The supraorbital and supratrochlear arteries branch off of the ophthalmic artery and supply the forehead. The supraorbital artery runs through the supraorbital notch (foramen in 8%)[1] and can usually be palpated with one's finger. There are 15 to 20 short posterior ciliary arteries leading to the choroid, 2 long posterior ciliary arteries to the iris circle, and 7 anterior ciliary arteries to the extraocular muscles. The superior and inferior venous systems drain into the cavernous sinus.[4]

The ligaments are important to signs of facial aging because tissue atrophy occurs along them. The main orbital ligaments are the lateral orbital thickening (known as the LOT) that adheres the eyelids to the lateral orbital rim and the orbitomalar ligament (orbicularis retaining ligament), which is a condensation fibrous tissue that attaches the skin to the inferior orbital rim and orbital septum along the arcus marginalis and defines the superior edge of the SOOF.[5] The zygomatic ligament not only suspends the zygomaticus major and zygomaticus minor muscles to the malar eminence but there are osseocutaneous attachments that connect the skin over the zygoma's malar eminence and demarcate the inferior edge of the SOOF.[6]

Periocular Aging

The skin, fat, muscles, and bones change and rotate with aging, and not all orbits age in the same manner. Older patients with dermatochalasis (excess skin fat and muscle) often undergo rejuvenation with blepharoplasty, a brow-lift, and a midface-lift, but many atrophic changes can be improved with facial fillers.[7,8]

As adults age, the soft tissue along the ligaments begins to show atrophy, prime signs of aging that are often improved with fillers. Atrophy along the orbitomalar ligament along the infraorbital rim creates a depressed tear trough, which is an early sign of aging. A 3-point grading system reported by Hirmand[8] describes the severity of progressive hallowing. There also is atrophy along the zygomatic cutaneous ligament that creates the malar hollow. The SOOF appears to be more prominent when these areas above and below show atrophy, which creates the look of an unwanted bag known as a festoon. Additionally, there is atrophy along the superior orbital notch where the ophthalmic branch of the trigeminal nerve (V1) and the supraorbital artery traverse. Soft-tissue atrophy along the supraorbital notch resembles the peak at the top of the letter A, giving the slang term *A-frame deformity*.

Periocular fat can atrophy, hypertrophy, herniate forward as the septum weakens, or become ptotic. Some patients develop hypertrophy and herniation of the superior and inferior orbital fat-pads, while others develop unwanted atrophy leaving a hollow superior orbit and loss of support to the levator muscle that contributes to eyelid ptosis. The frontalis fat deflates, leaving veins, arteries, and the hypertrophied corrugators unwantedly visible. Loss of subcutaneous fat in the glabella contributes to the formation of frown lines between the brows (also called number 11's). The ROOF deflates in some patients adding to brow ptosis. Loss of the facial frame occurs when temple fat atrophies.

Skeletal rotation also occurs. Throughout a patient's life, the skeleton remodels itself via activity of osteoclasts and osteoblasts. Pessa et al[9,10] has described the expansion of the anterior orbital aperture superomedially and inferolaterally as well as maxillary retrusion that results in angular changes of the midface in relation to the orbital rim. Lambros' algorithm describes the rotational changes of the cranium where the superior orbit protrudes as the maxilla retreats posteriorly.[9-11] The equator of the globe does not change its distance from the ROOF of the orbit, presumably because of its suspension in the orbit by the optic nerve after it passes through the optic canal and trochlea via the superior oblique muscle, but the distance of the inferior equator of the globe to the floor of the orbit increases as the floor of the orbit descends.[12]

Dermal Fillers for Periocular Rejuvenation

Hyaluronic acid (HA) was first pioneered for use in humans in the late 1970s by ophthalmologists for anterior segment surgery.[13-15] Biocompatibility for orthopedic and dermal applications was explored in the early 1990s.[16]

At this time, no dermal filler is approved by the US Food and Drug Administration for use in the periorbital area. Some fillers are approved for subdermal areas extending to the preperiosteal plane and can be used in the midface such as HA fillers (eg, Restylane Lyft [Galderma Laboratories, LP]), Juvéderm Voluma XC [Allergan, Inc]), poly-L-lactic acid (PLLA), and calcium hydroxylapatite (CaHA). No dermal fillers are approved for use in the forehead, glabella, or temples. Their use is becoming increasingly popular but is considered off label. In addition, cannulas are not approved for use in these areas. Cannulas may be beneficial in that they are thought to create less bruising and have less chance of entering a vessel than needles, but some injectors prefer needles because they are stiffer and therefore more precise.

The ideal filler for the tear trough, superior sulcus, ROOF, over the orbitomalar ligament, forehead, and glabella is one that is somewhat moldable but does not migrate, is not hydrophilic, is smooth to inject, and is reversible should there be any complications. No single filler fits this ideal description, but HAs typically are the first choice.

In vitro studies to determine the stiffness (G') and the ability to flow (viscosity) have been performed.[17,18] Calcium hydroxylapatite has the most stiffness, while Belotero Balance (Merz Aesthetics) and Juvéderm Ultra XC (Allergan, Inc) are more soft[17] (Table). These guidelines are important but may not correlate directly with how the fillers behave in vivo as demonstrated in animal models.[18]

Rheological Properties of Facial Fillers[19-23]

Product (Manufacturer)	Cross-linking Technology	G', Pa[a]	Viscosity, η or μ	Concentration, mg/mL	Cohesivity	Hydrophilicity
Radiesse (Merz Aesthetics)		1407	349,830			
Radiesse (+) Lidocaine (Merz Aesthetics)		1165	310,305			
Restylane-L (Galderma Laboratories, LP)	Biphasic, NASHA, BDDE	565	131,310	20	1.3 (least cohesive)[b]	
Restylane Lyft (Galderma Laboratories, LP)	Biphasic, NASHA, BDDE	549	127,090	20	1.7[b]	
Restylane (Galderma Laboratories, LP)	Biphasic, NASHA, BDDE	514	119,180	20		
Restylane Silk (Galderma Laboratories, LP)	Biphasic, NASHA, BDDE	344		20		
Juvéderm Voluma XC (Allergan, Inc)	Monophasic, monodensified, Vycross (high- and low-molecular-weight), BDDE	274, 398[c]	92,902	20	40, 2.4[b]	Decreased water absorption
Juvéderm Volbella XC (Allergan, Inc)	Monophasic, monodensified, Vycross, BDDE			15	19	Decreased water absorption
Prevelle Silk (Mentor Worldwide LLC)	Avian-derived divinyl sulfone	230		5.5		
Belotero Balance (Merz Aesthetics)	Monophasic, polydensified, CPM, BDDE	30	9217	22.5	5 (most cohesive)[b]	
Juvéderm Ultra XC (Allergan, Inc)	Monophasic, monodensified, Hylacross, BDDE	28, 207[c]	7307	24	96, 4.9[b]	Increased water absorption

Abbreviations: NASHA, nonanimal stabilized hyaluronic acid; BDDE, 1,4-butanediol diglycidyl ether; CPM, cohesive polydensified matrix.
[a]Measured using a rheometer.
[b]Created on the Gavard-Sundaram cohesivity scale, which was derived from measurements of viscosity in gram force.[22]
[c]Measurements made with a different rheometer.[22]

Hyaluronic acid fillers are produced by different technologies to create their cross-link patterns with 1,4-butanediol diglycidyl ether, which determines, to some degree, their behavior in human tissue. Fillers are either monophasic; monodensified; formed by Hylacross (Juvéderm), Vycross (Juvéderm Voluma XC, Juvéderm Volbella XC), or cohesive polydensified matrix technology (Belotero Balance), or biphasic, formed by nonanimal stabilized HA sieving technology (Restylane family). Biopsy has demonstrated that monophasic fillers tend to percolate through and integrate into the tissue, while biphasic fillers dissect tissue to the sides to create a potential space for the filler to reside (Table).[24]

Periocular Injection Considerations

An experienced injector is one who has developed not only an artistic eye for the face and excellent sense of anatomy but also has a sensitive ability to predict the filler-tissue interaction based on tactile feedback dependent on 3 main qualities: (1) stiffness and viscosity of the filler, (2) gauge of the needle or cannula, and (3) depth of the needle in the tissue. Periocular injections of dermal fillers can be delivered with needles or cannulas, diluted or undiluted. Smaller-gauge needles require more force than larger-gauge needles and cannulas that flow more freely. A needle in the dense dermis will require more force than one placed in the loose subcutaneous space.

The tear trough is generally preferable to fill with a mid-level G' HA filler that is less apt to migrate. A neutral gaze during the injection is preferred because closing or moving the eyes can distort the position of the inferior orbital fat-pads (Figure 1). A needle or cannula can be used, diluted or undiluted. The tear trough can be filled with the injection directed horizontally or vertically via a fanning technique. If needles are used, the skin should be stretched to view the 3 to 5 vertical veins and then the needle should be advanced beneath them to avoid bruising. Avoidance of hydrophilic fillers in the tear trough is important to avoid edema. The superior sulcus can be filled both anteriorly and posteriorly to the septum, which is a highly advanced injection for experienced injectors because of the proximity to the supratrochlear and supraorbital arteries as well as the superior ophthalmic vein (Figure 2). Sharp creases such as deep lateral periocular rhytides known as crow's-feet are nicely filled with intradermal HAs with a low G'.

Etched vertical glabellar rhytides fill well with low G' fillers in the intradermal layer, often best used in conjunction with neuromodulators. The glabella also can be filled in the preperiosteal plane that is deep, but mid levels in the procerus and pregaleal planes are dangerous because this level is where the arteries may become embolized. The ROOF can be reinflated with a variety of HAs and often is filled with a cannula to avoid the large transverse artery that anastomoses the temple circulation with the superior orbital artery. The forehead can be filled with point injections on the periosteum just superior to the corrugators but only lateral to an imaginary line passing through the superior orbital notch to avoid the supraorbital artery. Alternatively, a low G' filler can be diluted and then introduced superiorly with a cannula in the pregaleal plane from the superior forehead and then massaged inferiorly down toward the corrugators.[25]

Adding volume to the midface is important because it is the continuum of the lower eyelid. Fillers can be injected into multiple levels in this area: deep (to act as pillars to lift the malar eminence and replace bone that has rotated and soft tissue that has become atrophic or descended) and subcutaneous (to efface soft tissue along the zygomatic cutaneous ligament). Higher G' HA fillers and CaHA often are used in the midface along with PLLA. Facial framing of the temples, lateral cheeks, and preauricular area is often accomplished with PLLA but also can be done with mid to high G' HA fillers or CaHA. A cannula may be used to undermine and break apart the zygomatic cutaneous ligament's cutaneous attachments prior to delivery of the filler in the subcutaneous plane.[26] If not done, filler may track away from the hollow area where the ligament is attached and instead move to adjacent areas that will accentuate the hollow and make it look worse.

The temples and lateral face often are filled with PLLA for framing. Mid or high G' HA fillers and CaHA also are used in the temples both beneath the temporalis muscle and also above the deep temporalis fascia or sometimes in the subcutaneous plane.[27]

Prevention and Management of Periocular Complications

Blindness is the most devastating periocular complication of facial fillers, which is caused by retrograde arterial embolization followed by anterograde flow into the ophthalmic then central retinal arteries. Injectables that have caused blindness include (in descending order of frequency) fat, HA, collagen, paraffin, polymethyl methacrylate, silicone, PLLA, CaHA, polyacrylamide hydrogel, and micronized acellular dermal matrix. Of the 98 cases of blindness from periocular complications from dermal fillers reported in the world literature, the order of affected sites include the glabella (38 cases), nose (25), nasolabial folds (13), superior forehead (12), infraorbital rim (6),

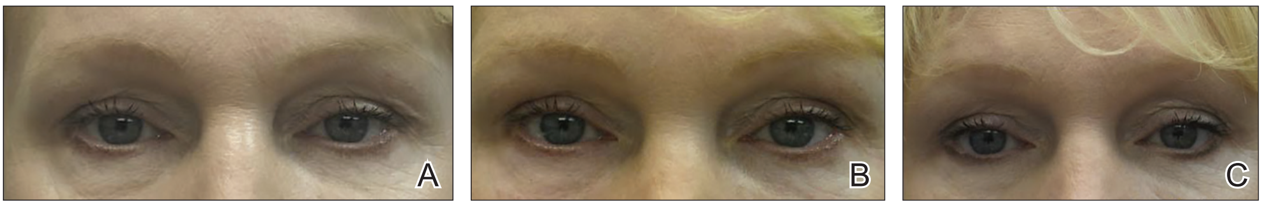

Figure 1. Patient with a tear trough deformity before (A), 5 minutes after injection with Restylane (Galderma Laboratories, LP) in a 30-gauge needle (B), and 1 week later (C).

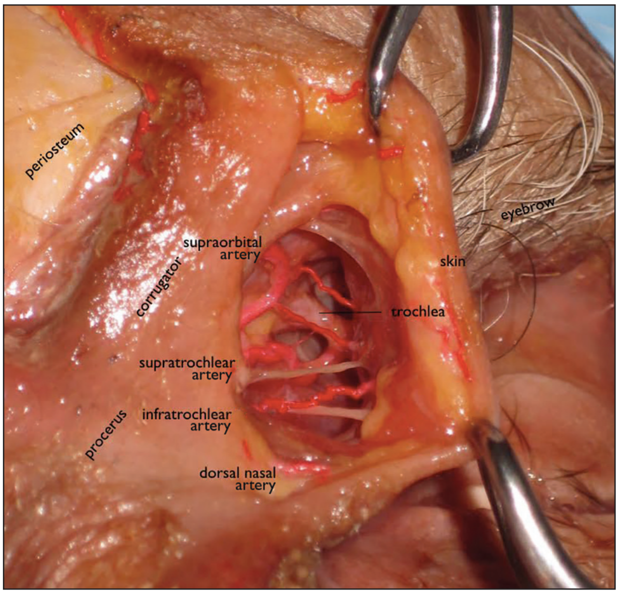

Figure 2. The skin of the glabella is deflected laterally so the corrugator and procerus muscles are left medially. The left superior medial orbit is exposed to show the large vessels in this area, making it the primary danger zone while injecting facial fillers. Image courtesy of Julie A. Woodward, MD.

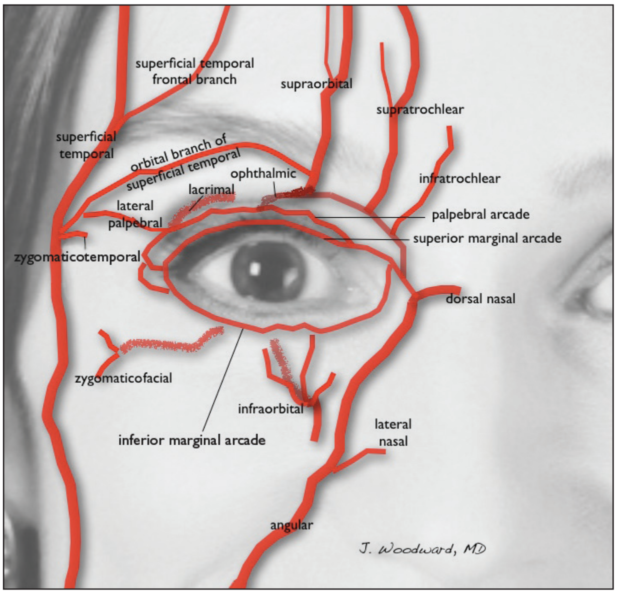

Figure 3. Drawing of periocular arterial anatomy. Image courtesy of Julie A. Woodward, MD.

temples (1), malar area (1), lip (1), and chin (1). Prevention includes avoidance of danger zone arteries including the supratrochlear, supraorbital, dorsal nasal, angular, infraorbital, zygomaticofacial and zygomaticotemporal arteries.[28]

Avoiding the average critical volume of 0.84 in any single aliquot dispensed is key to avoid filling of these periocular arteries to the critical bifurcation point that can result in anterograde flow into the eye (Freudenthal Nicolau syndrome). The smallest supratrochlear artery's volume in this study was 0.04 cc, so aliquots that do not exceed 0.03 cc are ideal.[29,30]

The injector should always be thinking about the anatomy of the danger zones (eg, infratrochlear and supratrochlear arteries, supraorbital artery, frontal branch of the superficial temporal artery, lacrimal artery, dorsal nasal artery, infraorbital artery, angular artery, zygomaticofacial artery, zygomaticotemporal artery)(Figure 3).

Hyaluronidase can be used off label to hydrolyze unwanted HA. It was first used to aid transcutaneous hydration and was used by ophthalmologists in the 1960s and 1970s to promote the spread of anesthetics by retrobulbar injection.[31,32] It can penetrate through soft tissues and blood vessels.[33] It is therefore hypothesized that a retrobulbar injection of hyaluronidase could aid in a case of impending blindness[34] but has not been successfully accomplished to date. If vision is confirmed to be poor or there is no light perception, a retrobulbar injection of 300 U of hyaluronidase should be given immediately and then repeated in approximately 30 to 45 minutes. The retina begins to show permanent loss of function after being deprived of blood flow for just 97 minutes,[35] so there may not be time for an immediate ophthalmology consultation, though such a consultation would be ideal.

Aside from common complications such as bruising and swelling, granulomas and biofilms are well documented in the literature. There are a variety of algorithms to treat such complications, which can happen many weeks after the injection of a dermal filler or years after the injection of a semipermanent filler.[36] Postinjection periocular edema can occur years after the initial injection.[37,38] Other periocular complications of dermal fillers include nonischemic (eg, bluish hue, filler migration, infection, inflammation, lumps) and ischemic (eg, blindness, necrosis, ophthalmoplegia, ptosis) disturbances.

Conclusion

In summary, periocular injections of facial fillers are useful tools for rejuvenation of the upper face when used with great caution and respect for anatomy.

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