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Vascular Safe Zones for Facial Soft Tissue Filler Injections

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The number of soft tissue filler injections performed by aesthetic injectors has continued to increase over the last few years. To provide a high standard of safety and achieve individualized, reproducible, and long-lasting outcomes, aesthetic injectors must have a solid foundation in anatomy, facial biomechanics, rheology, and injection biomechanics. Adverse events associated with soft tissue filler injections can be severe, especially if the aesthetic injector unintentionally injects the soft tissue filler into the patient's arterial vascular circulation and the administered product reaches the arterial bloodstream. Although the face has a rich arterial vascular supply that may seem overwhelmingly complex, it can be broken down systematically according to its internal and external vascular territories. To provide guidance for aesthetic practitioners performing minimally invasive facial injections for aesthetic purposes, this narrative article will discuss the course, depth, and branching pattern of the facial arteries based on the most frequently injected anatomical regions. In this article, we focus on vascular *safe zones* rather than *danger zones*.

The number of minimally invasive facial aesthetic procedures being performed by plastic surgeons has increased over the last few years (American Society of Plastic Surgeons [ASPS], 2020) and has continued to grow throughout the COVID-19 pandemic (ASPS, 2021). The increase in the popularity of these procedures can be partially explained by their cost-effectiveness, short procedure time, and quick recovery period when compared with other surgical facial interventions such as facelift, autologous fat grafting, or blepharoplasty. Removing facial wrinkles, increasing lip volume, ameliorating age-related facial changes, and facial sculpting are aesthetic procedures that have gained widespread acceptance in today's society especially through the support of social media (Chen et al., 2019).

In the United States, medical doctors, physician associates, nurse practitioners, dentists, registered nurses, licensed practical nurses, and various other health care professionals may perform minimally invasive soft tissue filler injections. To provide a high standard of safety and achieve individualized, reproducible, and long-lasting outcomes, aesthetic injectors must have a solid foundation in anatomy, *facial biomechanics* (i.e., the function and motion of facial soft tissues), *rheology* (i.e., the deformation and flow of matter), and *injection biomechanics* (i.e., the study of optimal parameters for syringe-needle

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injection). Moreover, the practitioner's technical skills and knowledge should be combined with an aesthetic understanding and appreciation of individualized beauty, harmony, and facial proportions. Luckily, a plethora of scholarly courses provide such continuous education across the world and the scientific literature is slowly but steadily moving away from *eminence-based* (i.e., relying on opinion) to evidence-based knowledge.

Despite the severity of some adverse events associated with soft tissue filler injection published in the literature, the increase in the number of facial aesthetic minimally invasive procedures has not seen a proportional increase in adverse events (Ortiz et al., 2020). Comparing the number of aesthetic injections performed worldwide with the number of mild, moderate, or very severe adverse events confirms that adverse events are rare in this field, although the true number of adverse events might be higher than what is reported in the literature due to underreporting.

Adverse events associated with soft tissue filler injections can be severe, especially if the aesthetic injector unintentionally injects the arterial vascular circulation with soft tissue filler and the administered product reaches the patient's arterial bloodstream. All regions of the face are susceptible to arterial vascular complications but only a few of them are highly sensitive. Compromising these regions can result in very severe complications, such as injection-related visual compromise, which may result in reduced vision or blindness. The regions presenting the highest risk for causing injection-related visual compromise are the glabella, the forehead, and the nose (Beleznay et al., 2015; Beleznay et al., 2019; Kapoor et al., 2020). The explanation as to why these facial midline regions present the highest risk for causing an injection-related visual compromise is due to the underlying arterial vascular supply. The glabella, forehead, and nose are nourished by branches of the ophthalmic artery; therefore, if unintentionally administered into the arterial bloodstream, the product can be transported to the eye and its surrounding structures (Beleznay et al., 2015; Beleznay et al., 2019; Kapoor et al., 2020).

Notably, practitioners should not be afraid of what could potentially happen; just as in other aspects of life, fear is never a good advisor for actions. Rather, practitioners should be fully aware of the risks, potential consequences, and should be knowledgeable about how to treat adverse events if they occur. The general term used in the literature for defining areas where filler injection could lead to complications is *vascular danger zones*. In our opinion, this term is misleading and *reductionistic* (i.e., oversimplistic) because if the practitioner does not possess a profound three-dimensional anatomic knowledge, the entire face is a vascular danger zone. In addition, defining vascular danger zones does not address the knowledge gap of where the aesthetic injector may safely inject soft tissue filler once the danger zone is defined. Because the absence of danger does not guarantee 100% safety, we prefer the term *vascular safe zone* as being more appropriate, especially if the practitioner understands the anatomical third dimension (i.e., depth) of the vasculature. In this narrative article, we will discuss the course, depth, and branching pattern of the facial arteries, and provide safe injection techniques to guide practitioners who perform minimally invasive facial injections for aesthetic purposes.

INTERNAL AND EXTERNAL CAROTID ARTERY VASCULAR SYSTEM

The arterial vascular supply of the face can be divided into the internal and external carotid artery vascular territories (Geibprasert et al., 2009). Both territories provide arterial blood supply to the head and neck area, and both territories are highly interconnected (Table 1). However, they have distinct regions that they primarily supply, which allows for the classification of internal and external carotid artery territories.

The internal and the external carotid arteries are branches of the common carotid artery at the level of the mandibular angle. The internal carotid artery (ICA) travels toward the brain without any major arterial branches to the neck or the face, providing blood supply only to the neurocranium and the brain. The ICA also provides the arterial blood supply to structures that evolve embryologically from the primitive brain, such as the eyes and periorbital structures. The retina is supplied by the central retinal and ciliary arteries as they branch off the

TABLE 1 Branches of the Internal and External Carotid Artery System According to the Facial Regions

Facial region	Branch of the ICA	Branch of the ECA
Forehead	Supraorbital artery	Superficial temporal artery
Glabella	Supratrochlear artery	Angular artery
Periorbital	Zygomatico-facial artery; zygomatico-temporal artery	Transverse facial artery; anterior deep temporal artery
Nose	Dorsal nasal artery; infraorbital artery	Angular artery; lateral nasal artery

Note. ECA = external carotid artery; ICA = internal carotid artery.

ophthalmic artery, which travels through the orbit. The glabella region, parts of the forehead, and the nose are supplied predominantly by the internal vascular system via terminating branches of the ophthalmic artery, such as the supraorbital, supratrochlear, and dorsal nasal arteries (Charlick & Das, 2021; Cotofana & Lachman, 2019a; Sethi et al., 2021).

The external carotid artery (ECA) travels cranially and supplies all soft tissues of the head and the neck except the brain and the neurocranium. Important branches of the ECA are the facial artery, the maxillary artery (with its deep temporal branches), the infraorbital artery (with its midfacial branches), and the superficial temporal artery (Banks et al., 2009; Koziej et al., 2019; Wang et al., 2021).

In the following paragraphs, we will highlight the injection planes for the most frequently targeted facial regions. To guide practitioners toward safe minimally invasive soft tissue filler injections, we base these injection planes on the underlying vascular anatomy.

FACIAL REGIONS SUPPLIED BY THE ICA

Forehead

Clinical Indications

The forehead can be injected with soft tissue filler as a treatment for frontal hollowing, an age-related loss of frontal soft tissue thickness. The loss of soft tissue thickness in the forehead can unmask the underlying bone, which results in a flat or concave forehead with increased visibility of the bony ridges of the supraorbital rim or the temporal crest. Other clinical reasons to inject the forehead with soft tissue fillers include static horizontal forehead *rhytides* (i.e., fine lines, wrinkles) or lateral brow *ptosis* (i.e., drooping eye).

Arterial Vasculature

The forehead is supplied by the supratrochlear, the supraorbital, central forehead, paracentral, and superficial temporal arteries. The superficial temporal, paracentral, and central arteries are subdermal arteries, located in the superficial fatty layer of the forehead. Although the major branches of the supratrochlear and supraorbital arteries emerge from the respective foramen/notch in a deep plane, they do not travel in the supraperiosteal plane. Both arteries travel in the undersurface of the frontalis muscle within the retro-orbicularis oculi fat or within the retro-frontalis fat. Approximately 1.4 cm cranial to the superior orbital bony rim, the superficial branches of both supratrochlear and supraorbital arteries change their plane from the deep to the superficial aspect of the frontalis muscle and travel within the superficial fatty layer before connecting with other arteries. No major arteries are located within the supraperiosteal plane or intradermally (Cotofana & Lachman, 2019a; Cotofana et al., 2017a).

Suggested Injection Technique

For static horizontal forehead lines, the practitioner can perform very superficial, intradermal soft tissue filler injections. Because the injection resistance is high, we recommend using a small needle for the injection procedure. When applied here, the product is superficial to the frontal arterial vasculature.

For frontal hollowing and lateral eyebrow elevation, we recommend using a deep supraperiosteal injection approach, because the majority of the vessels are located superficially. Using a 22-gauge blunt-tip cannula and accessing the area from a lateral position provide a high degree of safety because of the large diameter of the cannula and the perpendicular position to the vessel pathway. Administering a local anesthetic using an *antegrade* (i.e., forward) application will help limit the patient's pain if the injector touches the periosteal branch of the supraorbital nerve while advancing the cannula.

Glabella

Clinical Indications

Patients frequently consult aesthetic practitioners for treatment of frown lines in the glabella region. Horizontal and vertical glabella lines are the result of muscular contraction of the corrugator supercilii, orbicularis oculi, and procerus muscles. Although dynamic lines are visible only during muscular contraction and are considered part of the natural facial expression, static frown lines do not subside during muscle relaxation and are often perceived as being related to negative emotions, or a tired, aged, or angry facial appearance (Heckmann et al., 2003).

Arterial Vasculature

The major arteries that practitioners should consider when injecting the glabella region are the supraorbital, supratrochlear, and dorsal nasal arteries. These arteries are terminating branches of the ophthalmic artery and have multiple connections between each other and the *contralateral* (i.e., opposite) facial side. The supraorbital and supratrochlear arteries emerge from their bony foramina/notches in the orbit and change planes to travel more superficially in a cranial direction. The dorsal nasal artery also emerges from the orbit but travels inferiorly beneath the orbicularis oculi muscle after piercing the orbital septum in proximity to the medial canthus. Recent data have shown that vertical glabellar lines cannot be considered reliable skin surface landmarks for determining the course of the supraorbital/supratrochlear arterial vasculature, as the vessels can be found medially and/or laterally (Cotofana et al., 2020a). In addition, their location is affected by the patient's muscle tone and can be deflected medially or laterally during muscle contraction (Cotofana et al., 2020a).

Suggested Injection Technique

We recommend a combined approach using neuromodulators and soft tissue fillers. The patient's muscular tone can be reduced by using neurotoxin injections that relax the muscles and reposition the tissues. The practitioner can then administer soft tissue fillers into the remaining depressions to further ameliorate the patient's frown lines. To avoid unintentional arterial injection, the aesthetic injector could inject the filler intradermally with a small needle and administer small *aliquots* (i.e., portions) at an injection angle perpendicular (i.e., 90°) to the wrinkle.

Notably, recent data deduced from surface electromyography measurements have shown that with advancing age, the muscle potential of the procerus and corrugator supercilii muscles increases. This facilitates the age-related transition from dynamic to static lines. Thus, providing early injection of neuromodulators may decrease the severity of a patient's static frown lines or even prevent their formation (Cotofana et al., 2021).

Nose

Clinical Indications

Sculpting the nose using soft tissue fillers has become extremely popular across the globe. Practitioners can use minimally invasive rhinoplasty to correct the nasal dorsum (i.e., smooth the nasal hump, augment the dorsal concavity), to increase nasal tip projection and smooth alar irregularities (Rohrich et al., 2022). Although injecting soft tissue fillers can augment tissue, it does not provide the high level of modification that surgical rhinoplasty does; however, there are several advantages to using soft tissue fillers that include reduced costs for both patients and physicians, short procedures and recovery times, and fewer peri-interventional complications (Jung et al., 2019; Kassir et al., 2021).

Arterial Vasculature

The nose is a highly vascularized region supplied mainly by the ICA system. The dorsal nasal artery is a terminal artery of the ophthalmic artery. It emerges from the depth of the orbit in the glabella region and runs inferiorly toward the nose. It has multiple connections with the angular artery (an extension of the facial artery and a branch of the external arterial system), palpebral arteries, supratrochlear artery, and contralateral dorsal nasal artery at the level of the procerus muscle at the nasal dorsum. In addition, the dorsal nasal artery receives vascularization from the ECA system via the lateral nasal artery, the infraorbital artery, and the superior labial artery (Cotofana & Lachman, 2019a). In most patients, the arterial vasculature courses superficially within the subcutaneous fatty layer of the nose at the radix, nasal dorsum, and nasal tip (Alfertshofer et al., 2021). With few exceptions, the supraperiosteal/supraperichondreal plane is considered an avascular plane (Alfertshofer et al., 2021).

Suggested Injection Techniques

Nasal injections are best performed in the deep (i.e., supraperiosteal/supraperichondreal) plane to avoid injuring the vasculature that travels more superficially. To ensure access to the deeper tissue planes of the nose, we recommend using a blunt tip cannula and selecting an entry point in the midline of the middle of the nose (Alfertshofer et al., 2021). Dermal access should not be attained at the tip of the nose, as this poses a risk for missing the deep tissue plane when advancing toward the *nasal radix* (i.e., the depression at the root of the nose) because the cannula may follow the oblique course of the procerus muscle toward a more superficial location cranially (Alfertshofer et al., 2021). Because of the rich vascularization of the nose, to further reduce the risk for adverse events, we recommend using safety measures that include aspirating before injecting, injecting slowly while applying low pressure, injecting small boluses of filler, and assessing the patient for sensation and pain while injecting (Signorini et al., 2016; Tseng et al., 2021).

FACIAL REGIONS SUPPLIED BY THE EXTERNAL VASCULAR SYSTEM

Temples

Clinical Indications

Temporal hollowing is a frequent sign of aging that practitioners can address using soft tissue fillers to ameliorate a skeletonized appearance (Cotofana et al., 2020b). The temporal concavity caused by temporal volume loss increases the visibility of its bony borders (i.e., temporal crest, zygomatic arch, lateral orbital rim).

Arterial Vasculature

The main arterial branches to consider when treating the temporal region are the superficial and deep temporal arteries (Wang et al., 2021). The superficial temporal artery is the most cranial branch of the ECA. It emerges just superior and anterior to the tragus of the ear and courses in a 45° trajectory toward the forehead (Cotofana et al., 2020b; O'Brien et al., 2013). In the temple area, it is enveloped by the superficial temporal fascia (Cotofana & Lachman, 2019a). After crossing the temporal crest into the forehead region, the artery changes plane to travel within the subcutaneous fatty layer. The deep temporal arteries branch off of the maxillary artery. The anterior and posterior branches can be found between 1.5 cm and 3 cm lateral to the lateral orbital rim. They course cranially within deep tissue planes and are located below the temporalis muscle (Cotofana & Lachman, 2019a).

Suggested Injection Technique

Several injection techniques have been described in the literature, including supraperiosteal (deep), interfascial, or subcutaneous (superficial) approaches. The subcutaneous plane provides a safe plane for injecting when using a cannula, as the strong superficial temporal fascia prevents piercing of the superficial temporal artery and provides a safety net for the practitioner (Cotofana et al., 2020b). To keep the retinacula cutis supplying the skin intact, practitioners should avoid very rigorous fanning of the cannula.

When administering injections to patients with advanced temporal hollowing, aesthetic injectors may also choose a deep injection plane. Temple injections can be performed safely at 1 cm up and 1 cm over, as measured from the fusion point of the temporal crest and supraorbital rim (Cotofana et al., 2020b). Practitioners should insert the needle perpendicular to the skin surface and establish firm contact with the bone. This provides a safe supraperiosteal plane of injection, without putting the deep temporal arteries at risk. Because of the layered arrangement of the face, injections into the temples can have pan-facial effects and improve the appearance of age-related tissue descent (Casabona et al., 2019; Hernandez et al., 2020). Evidence-based injection strategies have suggested performing the upper and lateral injections first (Casabona et al., 2019; Hernandez et al., 2020).

Tear Trough

Clinical Indications

The tear trough plays a major role in periorbital rejuvenation. It is frequently targeted to alleviate blue discoloration, tear trough deformity, and a nasojugal or palpebromalar groove (Bernardini et al., 2021; Calomeni et al., 2022).

Arterial Vasculature

Relevant vessels of the tear trough region are the angular artery and vein. The angular vein travels obliquely from lateral to medial within the tear trough region. Located approximately 4 mm inferior to the infraorbital rim, it courses within the sheets of the orbicularis oculi muscle (Calomeni et al., 2022). Piercing this vein can cause pain and significant bruising. There are no major arterial vessels in the midpupillary line or at the medial limbus. The angular artery is located medial to the medial canthus where it travels in a vertical pattern and is found medial to the angular vein (Calomeni et al., 2022).

Suggested Injection Technique

Many injection algorithms have been proposed for this region. In general, deep supraperiosteal injections can be performed safely using a needle or a cannula, targeting the suborbicularis oculi fat beneath the orbicularis oculi muscle and the deep cheek fat compartments. Using this deep tissue plane avoids injury of the vasculature, especially the angular vein, which courses more superficially within the orbicularis oculi muscle. If using a blunt-tip cannula, the practitioner can choose a dermal entry point at the intersection of a horizontal line extending from the nasal base, and a vertical line extending from the lateral canthus (Bernardini et al., 2021).

Nasolabial Fold

Clinical Indications

Prominent nasolabial folds are a major sign of facial aging. They are caused by age-related descent of the superficial nasolabial fat compartment that prolapses over its inferior border and the strong dermal insertion of the perioral and facial musculature at the nasolabial sulcus (Schenck et al., 2018a).

Arterial Vasculature

The exact course of the angular artery is difficult to predict in the nasolabial fold (Gelezhe et al., 2021; Wang et al., 2021). It travels in proximity to the nasolabial sulcus, coursing from the oral commissure to the nasal ala. Recent ultrasonography-based investigations have *abrogated* (i.e., disproven) the belief that the angular artery travels strictly subdermally by showing its location at variable depths (Cotofana et al., 2020b).

Suggested Injection Technique

Current injection algorithms have evolved from injections into the superficial nasolabial fat compartment (which can increase the severity of the nasolabial fold) or direct treatment of the nasolabial fold. Knowledge of the interwoven architecture of the fascial tissue layers has revolutionized nasolabial fold treatment regimens. Injecting the patient's temples, zygomatic arch, and upper midface (following the pan-facial application principle of injecting the upper face and lateral face first) might significantly indirectly improve the prominence of the nasolabial fold (Casabona et al., 2019). In addition, supraperiosteal injections using a needle in contact with the bone in the deep piriform space can provide a safe zone to alleviate the signs of aging associated with a prominent nasolabial fold (Cotofana et al., 2019; Surek et al., 2016). As noted previously, we recommend using safety measures that include aspirating before injecting, injecting slowly while applying low pressure, injecting small boluses of filler, and assessing the patient for sensation and pain while injecting (Signorini et al., 2016; Tsdeng et al., 2021).

Jawline

Clinical Indications

The definition of the lower face is primarily determined by the jawline. Because the jawline loses contour with

increasing age, several signs of facial aging can be found here. As individuals age, the jowl fat compartment follows the age-related inferior displacement of the underlying platysma, contributing to jowl deformity and a prominent labiomandibular sulcus (Cotofana & Lachman, 2019b).

Arterial Vasculature

In the jawline, the facial artery travels deep to the platysma, anterior to the accompanying vein (Schenck et al., 2018b). It is located anterior to the masseter muscle, where it can be palpated for confirmation.

Suggested Injection Technique

The artery is located deep; therefore, superficial injections within the subcutaneous plane can safely be performed to enhance the jawline and augment the frame of the face. Using a cannula in this area and elevating the skin can help the practitioner confirm injection into the subdermal plane. No major relevant artery is located at the mandibular angle. Therefore, deep and superficial injections can be performed safely using both a needle and a cannula (Suwanchinda et al., 2018). If using a cannula, an entry point at the middle of the mandible provides access to the mandibular angle and the labiomandibular sulcus (Freytag et al., 2019).

Lips

Clinical Indications

The lips play an important role in verbal and nonverbal communication, social interaction, and sexual attraction. Lack of lip definition and atrophy of the lips are a result of age-related changes of facial soft tissues, underlying maxillary bone, and *dentition* (i.e., condition of the teeth; Cotofana et al., 2018a; Cotofana et al., 2018b). For this reason, lip augmentation and contouring are among the most popular minimally invasive facial procedures performed in clinical practice (Cotofana et al, 2017b; Cotofana et al., 2020c).

Arterial Vasculature

At the *modiolus*, which is a point at the corner of the mouth where eight muscles meet, the inferior and superior labial arteries branch off the facial artery to the lips. Despite various anatomic variations described in the literature, the most frequently observed plane for the labial arteries is the deep plane; the artery is located deep to the orbicularis oris muscle and right next to the oral mucosa (Cotofana et al, 2017b; Cotofana et al., 2020c). When the patient's lip is everted, the practitioner can detect the pulsating artery. In most cases, the artery courses within the red of the patient's lip especially in the midline (Cotofana et al., 2020c).

Suggested Injection Technique

The course of the arterial vasculature supports superficial injections in the subcutaneous plane. Practitioners can perform injections superficially, using multiple injection points and small bolus injections with a needle. Using perpendicular injections increases patient safety by reducing the potential for the needle to contact the arterial wall.

TABLE 2 Facial Safe Zones for Injecting Soft Tissue Fillers According to the Facial Regions and Arterial Vasculature

Facial region	Arterial vasculature	Safe zone for injection
Forehead	Central artery Paracentral artery Supraorbital artery Supratrochlear artery Superficial temporal artery	Intradermal and supraperiosteal
Glabella	Supraorbital artery Supratrochlear artery Dorsal nasal artery	Intradermal
Temple	Superficial temporal artery Deep temporal artery	Superficial within the subcutaneous fatty layer and supraperiosteal considering the course of the deep arteries
Nose	Dorsal nasal artery Angular artery Infraorbital artery	Supraperiosteal/Supraperichondreal
Tear trough	Angular artery and vein	Supraperiosteal
Nasolabial	Angular artery	Supraperiosteal in the deep pyriform space or intradermal
Jawline	Facial artery	Superficial within the subcutaneous fatty layer
Lips	Superior and inferior labial artery	Subdermal

CONCLUSIONS

Severe complications after soft tissue filler injections can sometimes be traced back to unintentional injection of filler material into the patient's arterial vascular system. Because of the location of the underlying vascular anatomy, some facial regions are more susceptible to this complication than others. However, aesthetic injectors may more safely inject soft tissue fillers in tissue layers without major vascular structures (Table 2). Thus, knowledge of the facial anatomy is fundamental when injecting all soft tissue fillers. Understanding the location as well as the course and depth of the facial vasculature will reduce risk and increase patient safety (Cotofana & Lachman, 2019a; Gelezhe et al., 2021; Gombolevskiy et al., 2021). By adhering to the guidelines we have provided, practitioners can perform soft tissue filler injections with greater safety and efficacy.

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