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The infraorbital artery: Clinical relevance in esthetic medicine and identification of danger zones of the midface

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Summary *Background:* Over the past decade, cosmetic injections of dermal fillers or fat have become a popular procedure in facial rejuvenation in an overconsuming society. However, complications such as arterial embolism and occlusion can occur even with experienced injectors, especially in high-risks zones namely the glabella, the nasal dorsum or the nasolabial fold. The aim of this study was to define the vascular danger zones of the infraorbital area in order to provide guidelines helping avoid them.
Materials and methods: The infraorbital artery, its main branches and their anastomoses with neighbouring vessels were studied in 18 fresh cadavers. Mimetic injections of inked hyaluronic acid were performed in the infraorbital area in the interest of analyzing its distribution and to determine potential vascular risks towards the infraorbital artery and its branches.
Results: The infraorbital artery and its branches were located in common injection regions and anastomosed to the supratrochlear artery, the dorsal nasal artery and the angular artery through the nasal branch of the infraorbital artery. Two danger zones could be depicted: injections can be risky when performed too superficially in the midcheek area, and likewise risky

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when performed in a periosteal layer in infraorbital hollow or tear-trough correction, because of an obvious possibility of retrograde embolism.
Conclusion: The infraorbital artery can be involved in anatomic mechanism of arterial occlusion, further blindness and stroke, among the related neighbouring arteries. Based on the findings of this study, injections to the periosteum layer in tear-trough correction and above the periosteum on the zygomatic arch is not advised.

Introduction

Facial soft-tissue fillers have been exponentially used over the past decade and have become a popular alternative to surgical rejuvenation of the face. However, as the field of soft tissue augmentation has become increasingly popular, occurrence of complications, even with experienced injectors, has augmented and is supposedly underreported.[1]

Filler complications are largely divided into minor and major complications. Minor complications of early onset such as bruising, swelling, and erythema are relatively common and may be considered as adverse sequelae rather than true complications. Delayed hypersensitivity reaction is a minor complication of late onset. More significant complications include overcorrection, surface irregularities, filler visibility, Tyndall effect, and granuloma formation. Complications of greater severity are visual impairment, skin necrosis, anaphylaxis stroke and even death. The most severe complications generally occur secondary to inadvertent damage or cannulation of the vessels.[2-6] Mechanisms are still unclear: extravascular compression or intravascular obstructions are mostly described.

Having a thorough understanding of the vascular anatomy before injecting is critical. Therefore, when injecting into the cheek or infraorbital area, knowledge of the infraorbital artery's anatomy (IOA) and its branches is necessary to prevent possible adverse events.

In this article, we describe, by means of a cadaveric dissection, the pertinent anatomy of the IOA, and we identify the infraorbital danger zones in order to maximize safety during filler injections.

Materials and methods

This single-centre study was conducted in accordance with the declaration of Helsinki. The cadavers were provided by the Anatomy Department of the Faculty of Medicine and were official donations to the anatomical student course and for medical research purposes. The donor sites showed no visible scar or tissue damage, and the medical history revealed no prior surgical intervention to the head and neck area. This study included 19 cadaveric hemifaces.

Pertinent anatomy of arteries

After proper preparation and cervical dissection in 18 cadaveric hemifaces, sixty cubic centimetres of a red-inked latex solution were injected into the common carotid artery. The cadavers were furtherly stored at 4 °C for 48 h before facial dissection. We performed a combined subciliary and Weber Ferguson approach, followed by supberiosteal dissection, aiming to identify the infraorbital hiatus and corresponding vessels. Analyses of the vascular patterns were done after identification of the main branches of the IOA involved in enhancement of the infraorbital area, namely the zygomaticomalar (ZMB) and nasal branches (NB). The following features were then recorded: depth and pathway of each branch, anastomoses with related vessels and endpoint.

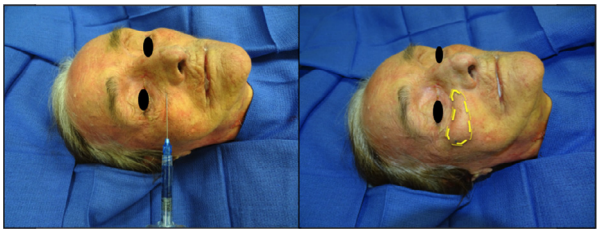

Figure 1 Cadaveric photographs showing deep medial cheek compartment enhancement with blue-coloured hyaluronic acid amounting 3cc. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Mimetic injections

To illustrate relevant anatomical structures and features following filler injection into the infraorbital area, we used mimetic injections of inked hyaluronic acid in a fresh cadaver of an 81-year old female body donor. For this purpose, we added methylene blue (Carmyne®, 40 mg/5 mL) to syringes of hyaluronic acid (HA) – (Stylage L®, Vivacy, 1 mL) and volumization of the lateral and medial infraorbital area with a 22-G blunt cannula.

We performed a supraperiosteal injection at the anterior edge of the zygomatic bone, towards the infraorbital rim with retrograde deposits (vertical supraperiosteal depot technique). We also completed superficial tear-trough correction with linear threading (Figure 1).

Further dissection allowed determination of the accurate positioning of the filler and the vascular risk to the IOA. The facial skin of the cadaver was removed, followed by the underlying layers: the malar fat pad was exposed, then the SOOF (suborbicularis oculi fat), before clear visualisation of the infraorbital osseous rim and its hiatus. The origin of the

infraorbital artery was identified and its course followed by means of an anterograde dissection until division into terminal branches. The overlying muscles and subcutaneous tissue around the IOA were removed to allow determination of the overall course of the artery and placement of the filler along (video). The relationships between injected filler and related arteries were investigated.

Description of danger zones

Brennan et al. defined "danger zones" as regions of the face at a higher risk for complications due to the structures that lie beneath the skin (e.g., vessels or nerves) and to avoid during dermal filler/volume enhancer injection process.[7] It was considered as one, where specific and unpredictable vascular injury and/or intra-arterial injection could occur regarding anatomical location of vascular structures, inventory of prior facial surgeries and history of previous soft tissue fillers.[8] We tried to determine the anatomical correlation and physiopathology of retrograde embolism and arterial occlusion, through vascular anastomoses between the IOA's branches and the pathway leading to the internal carotid system. The data collected allowed us to establish the vascular danger zones of the infraorbital area.

Results

Distribution of arteries involved in infraorbital volumization

18 hemifaces of cadaveric specimens were included in this analysis. IOA, supratrochlear artery (STA), dorsal nasal artery (DNA) and angular artery (AA) have been dissected.

Three main branches could be described when depicting the IOA, which hiatus was usually located on a vertical line crossing the medial border of the pupil or in-line with the first premolar, second premolar, and the canine teeth, an average of 9.1 mm below the infraorbital rim (Figure 2).

When exiting the infraorbital hiatus, the main branches of the IOA were situated in a periosteal layer. The ZMB was found in 14 hemifaces, and the NB in 17 hemifaces. The mean calibres were respectively 0.5 and 0.6 mm for the NB and the ZMB. The ZMB became superficial around 17 mm medial to the edge of the zygomatic arch, and ran through the malar fat pad before ending at the skin of the cheek. The path of the NB strictly remained in a periosteal plane before anastomosing with the angular artery, the dorsal nasal artery, or directly with the supratrochlear artery (Figure 3).

Dermal filler distribution into the infraorbital area

After supraperiosteal injections we found that the filler product diffused over the SOOF and beyond the malar fat pad, in a constricted area between the facial retaining ligaments (tear trough ligament medially, orbital retaining ligament laterally and the zygomatic cutaneous ligament below) and fibrous septa, which are loose in this elderly cadaveric female.

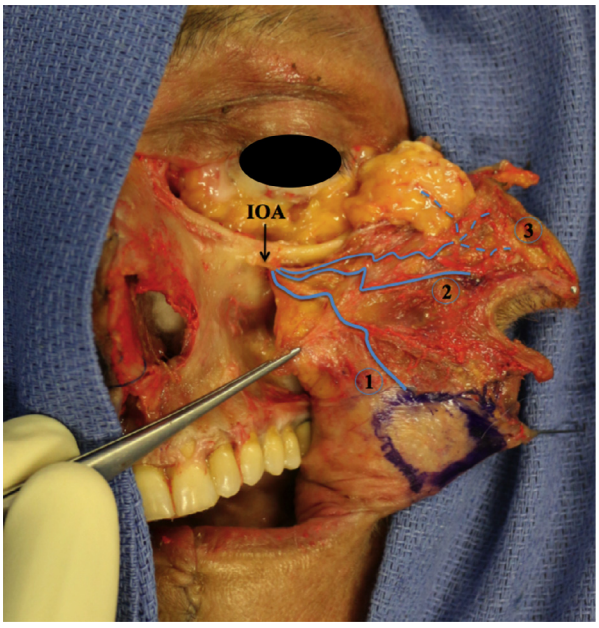

Figure 2 Cadaveric view following subperiosteal dissection. The IOA and its main branches' pathways are depicted. 1: vestibular branch, 2: nasal branch, 3: zygomaticomalar branch.

The infraorbital artery and its branches were dyed (Figure 4(A)-(D)).

A comprehensive video shows that intravascular injury of the main IOA trunk is unlikely to be caused by perpendicular injection to the axis of the IOA in a sagittal plane, from lateral to medial (Figure 5). Moving the cannula back and forth may perforate the IOA but intravascular dissemination is believed to be very rare. The ZMB and NB are parallel to the axis of injection, implying higher risk of intra-arterial injection. Moreover, high cohesive hyaluronic acid used in cheek enhancement may obturate the IOA proximally in case of intra-arterial injection.

Identification of danger zones

Based on the anatomical findings, two major danger zones could be described in the infraorbital area (Figure 6):

First, tear-trough deformity and infraorbital hollow correction is risky when injections are performed in a periosteal layer because of anastomoses of the NB (present in 94% of the cases) to the STA, DNA or AA. The danger zone is located between a line crossing the medial pupil and the lateral nasal wall. Safe practice consists of retromuscular, pre-orbital fat injections.

Second, in cheekbone enhancement, risk of skin necrosis may occur in superficial injections on the edge of the zygomatic bone because of the existence of cutaneous perforators of the ZMB in 77% of the cases. The danger zone is the lateral third of the zygomatic bone, where injections have to be performed in supraperiosteal layers.

Possible retrograde embolization of filler product into the internal carotid system, can lead to mostly irreversible complications such as blindness and cerebral infarction. The main pathways involve, in tear-trough deformity correction,

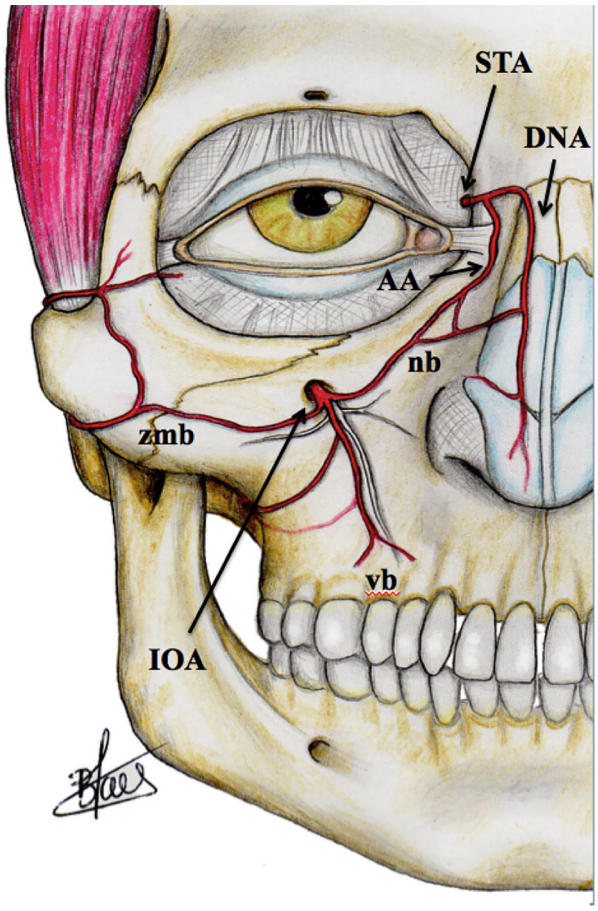

Figure 3 Illustration of the IAO and its main branches according to Hufschmidt et al.* IOA: infraorbital artery; zmb: zygomatico-malar branch; vb: vestibular branch; nb: nasal branch; AA: angular artery; STA: supratrochlear artery; DNA: dorsal nasal artery.

filler migration into the supratrochlear artery, the dorsal nasal artery or the angular artery (Figure 5), routes connecting the external to the internal carotid system.

Discussion

Anticipating the depth and course of vessels allows practitioners to develop techniques to avoid intravascular injection, vascular injury and/or compression. Even if most complications occurring with fillers are mild, transient and reversible, recent publications arouse aestheticians' and surgeons' awareness to the potential vascular risks of fillers on the face.[2-5] Consequently, understanding the anatomy of the vascular patterns and neighbouring arteries is crucial to safely perform injections.

A vascular injury following accidental intra-arterial injection is related to a technical error and may induce adverse events as mild as erythema and severe as skin necrosis. Further, exceptional cases of visual impairment or cerebral infarction have been reported due to retrograde flow and anastomoses between internal and external carotid systems, leading to arterial obstruction and ischemia.[1,9-12]

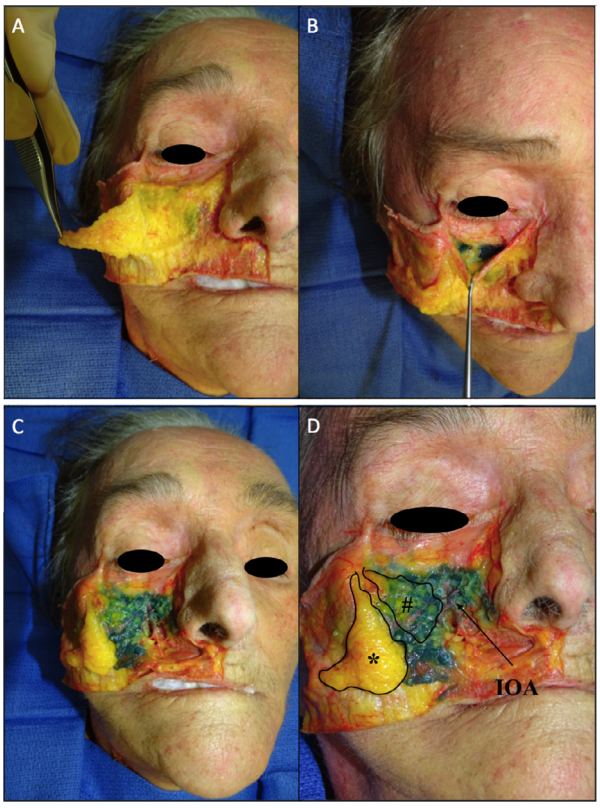

Figure 4 (A) and (B). Cadaveric views A and B illustrate, after reflection of the cutaneous layer and malar fat pad, the positioning of the blue-inked dermal filler around the vessels. (A) illustrates dissection after reflection of the cutaneous layer and the malar fat pad. A slight contact existed because of coloration of the facial vessels, and the filler placed below the arcus marginalis. (C) and (D). Cadaveric views (C) and (D) allow deep cheek compartment visualization of the inked filler around the infraorbital artery (IOA) and related branches. *: malar fat pad, #: SOOF (sub orbicularis oculi fat).

Mechanisms are still unclear: extravascular compression of the blood flow by surrounding filler or intravascular obstruction is mostly described.

Areas most at risk when using dermal fillers or autologous fat grafting are reported to be the glabella, the nasolabial folds and the nasal dorsum. When it comes to the type of filler used, autologous fat injections resulted in worse visual acuity and worse recovery rates when compared to hyaluronic acid, collagen or calcium hydroxylapatite injections.[9,13]

Infraorbital enhancement including cheek volumization, infraorbital hollow and tear-trough correction with fillers is one of the key steps in aesthetic rejuvenation of the face: as a matter of fact, they represent high-demanding zones of correction.[14] Taking the above into consideration, it was essential to study the common pattern of the infraorbital artery in order to identify danger zones with implication for cheek and tear-trough filler augmentation, as illustrated in Figure 3.[15-17]

In the present study, we found that the ZMB and the NB, which path and depth plane are different, are the main vessels at risk when performing aesthetic injections.

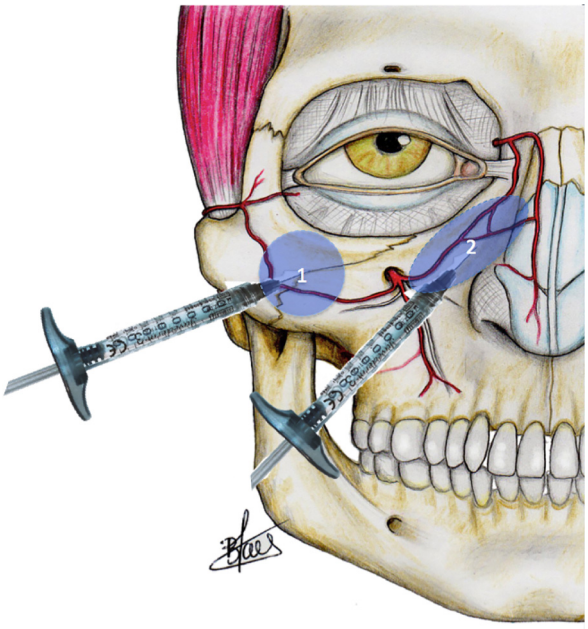

Figure 5 Common injection patterns in the infraorbital area: (1) supraperiosteal injection for malar enhancement and (2) retro-orbicularis oculi injection for tear trough deformity correction. Proximity to the IOA and its branches can be noted.

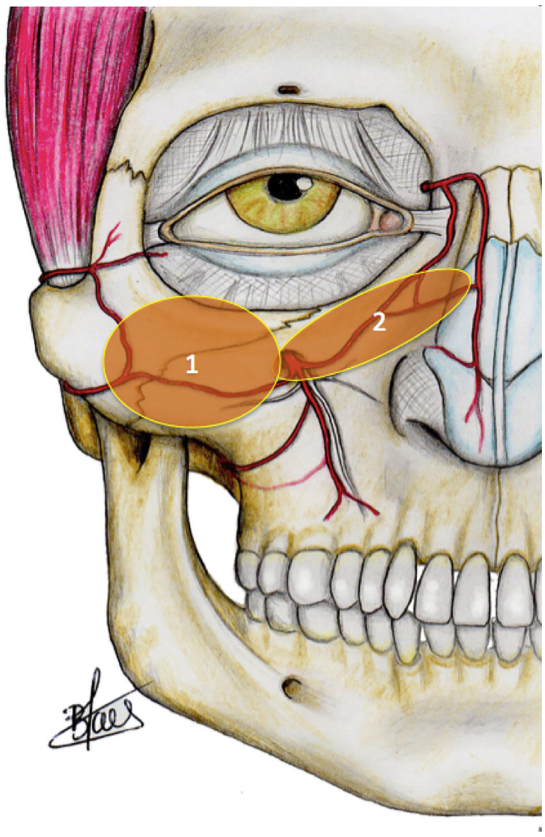

Figure 6 Illustration of danger zones in the infraorbital area: marked area 1 shows involvement of the zygomaticomalar branch with risk of skin necrosis through skin perforators, marked area 2 represents risk of arterial embolization into the internal carotid system through retrograde flow into the DNA and the STA, before reaching the ophthalmic, retinal artery, or even cerebral arteries.

Nevertheless, correction to either cheek or infraorbital hollow/tear-trough deformity is different because of the difference in thickness of the tissue between the bone and the skin.[18]

In the zygomatic area, the superficial injection might cause an injury to the ZMB of the IOA and induce skin necrosis through skin perforators.

In the medial cheek area, injection too deep on the periosteum might injure the NB of the IOA and induce worse complications through anastomoses with the internal carotid system. Subsequently occlusion of the ophthalmic and retinal arteries, or even cerebral arteries, with irreversible blindness and cerebral infarction might happen. The physiopathology of vision loss is explained by iatrogenic ophthalmic artery occlusion, followed by central retinal artery and further branch of the retinal artery occlusion, respectively. Consequently, cerebral emboli also might occur because of the proximity between ophthalmic and cerebral arteries.

Taking into account these anatomical findings, we propose specific recommendations with arbitrary landmarks. The midcheek can be separated by means of a vertical line running through the medial border of the pupil, into two distinct areas requiring specific approaches because of different inherent risks regarding intravascular injection. On the medial side of this line, injections might induce intravascular cannulation when performed to deeply in a periosteal layer. Further migration of the filler through the nasal branch of the infraorbital artery may occlude terminal vessels of the internal carotid circulation inducing cerebral and ocular compromise. It is thus advised to remove the cannula at least 2 mm from the periosteum and deliver the product in small aliquots by avoiding any resistance. On the other hand, laterally to this line, injections should be done on the periosteum to minimize risks of filler distribution into the zygomatico-malar cutaneous branches and its consequential danger of skin necrosis.

To our knowledge, the vascular risks following midcheek, deep medial cheek enhancement and tear-trough deformity correction with fillers have been poorly studied up-to-date. Wu et al. reported similar findings to ours with a cadaveric study of filler distribution and description of arteries most at risk in ophthalmic artery embolism.[19]

Loh et al. recently reported the only case of vascular complication involving the infraorbital artery with impending blanching of the malar area. Immediate treatment consisted of "high-dose pulsed hyaluronidase protocol" (1000-unit pulses) administered hourly, allowing recovery and complete healing.[20]

Scheuer et al. briefly described danger zones for several aesthetic units and formerly discouraged injecting the medial infraorbital region. They advised to deeply inject laterally and to push the filler medially if required.[21,22] Moreover, detailed expert guidelines have lately been established, recommending supraperiosteal injections of HA in cheek augmentation and retromuscular or supraperiosteal injections in infraorbital hollow correction.[18] Our study underlines specific caution in tear-trough correction.

Another important approach to decrease the risk of intra-arterial penetration is the use of cannulas. We found that the mean calibres of the IOA branches were 0.5 mm for the NB, 0.6 mm for the ZMB and 0.7 mm for the vestibular branch, which makes them too small to be injured using a cannula.

As evidenced by numerous studies, the facial vasculature has many variations and can be found in various tissue planes, depending on location within the face. Our study underlines the many routes and pathways with different depths between the arterial anastomoses. Reproducibility is hardly achievable, yet depicting the main anatomical variations may help improve injection techniques.

With the improvement of anatomical knowledge, the more important concern is to determine the appropriate depth of injection with optimal safety rather than defining the frontal view of the injection.

Conclusion

Although soft tissue fillers have a very favourable safety profile, adverse events can occur. Accidental intravascular filler injections are rare but potentially severe in the danger zones of the infraorbital area because of either possible retrograde embolism leading to extensive blindness, or skin necrosis. Accurate knowledge of anatomical skills and injection techniques with appropriate plane injection, emphasizing avoidance of danger zones, are mandatory to help prevent irreversible complications and ensure satisfactory, safe outcomes.

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Conflict of interest

The authors declare to have no conflict of interest, and no source of funding.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjps.2018.09.010.

References

1. Ozturk CN, Li Y, Tung R, Parker L, Piliang MP, Zins JE. Complications following injection of soft-tissue fillers. *Aesthet Surg J* 2013;**33**:862–77.
2. DeLorenzi C. Complications of injectable fillers, part I. *Aesthet Surg J* 2013;**33**:561–75.
3. DeLorenzi C. Complications of injectable fillers, part 2: vascular complications. *Aesthet Surg J* 2014;**34**:584–600.
4. Woodward J, Khan T, Martin J. Facial filler complications. *Fac Plast Surg Clin N Am* 2015;**23**:447–58.
5. Ferneini EM, Ferneini AM. An overview of vascular adverse events associated with facial soft tissue fillers: recognition, prevention, and treatment. *J Oral Maxillofac Surg* 2016;**74**:1630–6.
6. Jagdeo J, Hruza G. The Food and Drug Administration Safety Communication on Unintentional Injection of Soft-Tissue Filler Into Facial Blood Vessels. *Dermatol Surg* 2015;**41**(12):1372–4.
7. Brennan C. Avoiding the "danger zones" when injecting dermal fillers and volume enhancers. *Plast Surg Nurs* 2014;**34**:108–11 quiz 112-3.
8. Brennan C. The art of the aesthetic consultation. *Plast Surg Nurs* 2012;**32**:12–16 quiz 17- 8.
9. Park SW, Woo SJ, Park KH, Huh JW, Jung C, Kwon OK. Iatrogenic retinal artery occlusion caused by cosmetic facial filler injections. *Am J Ophthalmol* 2012;**154**:653–62 e1.
10. Hong DK, Seo YJ, Lee JH, Im M. Sudden visual loss and multiple cerebral infarction after autologous fat injection into the glabella. *Dermatol Surg* 2014;**40**:485–7.
11. Kim EG, Eom TK, Kang SJ. Severe visual loss and cerebral infarction after injection of hyaluronic acid gel. *J Craniofac Surg* 2014;**25**:684–6.
12. Lin YC, Chen WC, Liao WC, Hsia TC. Central retinal artery occlusion and brain infarctions after nasal filler injection. *QJM* 2015;**108**:731–2.
13. Lazzeri D, Agostini T, Figus M, Nardi M, Pantaloni M, Lazzeri S. Blindness following cosmetic injections of the face. *Plast Reconstr Surg* 2012;**129**:995–1012.
14. Gassner HG, Rafii A, Young A, Murakami C, Moe KS, Larrabee WF Jr. Surgical anatomy of the face: implications for modern face-lift techniques. *Arch Fac Plast Surg* 2008;**10**:9–19.
15. Aziz SR, Marchena JM, Puran A. Anatomic characteristics of the infraorbital foramen: a cadaver study. *J Oral Maxillofac Surg* 2000;**58**:992–6.
16. Raschke R, Hazani R, Yaremchuk MJ. Identifying a safe zone for midface augmentation using anatomic landmarks for the infraorbital foramen. *Aesthet Surg J* 2013;**33**:13–18.
17. Li X, Du L, Lu JJ. A novel hypothesis of visual loss secondary to cosmetic facial filler injection. *Ann Plast Surg* 2015;**75**:258–260.
18. Carruthers J, Rzany B, Sattler G, Carruthers A. Anatomic guidelines for augmentation of the cheek and infraorbital hollow. *Dermatol Surg* 2012;**38**:1223–33.
19. Wu S, Pan L, Wu H, et al. Anatomic study of ophthalmic artery embolism following cosmetic injection. *J Craniofac Surg* 2017;**28**:1578–81.
20. Loh KTD, Phoon YS, Phua V, Kapoor KM. Successfully managing impending skin necrosis following hyaluronic acid filler injection, using high-dose pulsed hyaluronidase. *Plast Reconstr Surg Glob Open* 2018;**6**:e1639.
21. Scheuer JF 3rd, Sieber DA, Pezeshk RA, Gassman AA, Campbell CF, Rohrich RJ. Facial danger zones: techniques to maximize safety during soft-tissue filler injections. *Plast Reconstr Surg* 2017;**139**:1103–8.
22. Scheuer JF 3rd, Sieber DA, Pezeshk RA, Campbell CF, Gassman AA, Rohrich RJ. Anatomy of the facial danger zones: maximizing safety during soft-tissue filler injections. *Plast Reconstr Surg* 2017;**139**:50e–58e.