Identifying a Safe Zone for Midface Augmentation Using Anatomic Landmarks for the Infraorbital Foramen

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Abstract

Background: Midface augmentation is commonly used to improve the appearance of concave faces and to achieve balance in the facial contour. It can also be an adjunct to orthognathic or reconstructive surgery. However, an inherent risk of midface augmentation is injury to the infraorbital nerve where it exits the infraorbital foramen (IOF). This can result in significant morbidity, including loss of sensation to the midface, nasal sidewall, upper lip, and lower eyelid.
Objectives: The authors identify a safe zone of dissection in the midface for subperiosteal placement of infraorbital, paranasal, malar, and submalar implants, which avoids injury to the infraorbital nerve.
Methods: Given the popularity of transconjuctival and intraoral access to the midface skeleton, the authors identified relevant bony and dental landmarks from radiographic images and measured distances between the IOF and these landmarks. Forty-four computed tomography scans of adult hemifaces were used to accurately locate the IOF in relation to the anatomic landmarks.
Results: Most often, the IOF's location correlated with the second premolar on a vertical axis. The average distance between the IOF and the infraorbital rim, piriform aperture, tip of the second premolar cusps, and lateral orbital rim was approximately 8.61, 17.43, 41.81, and 25.93 mm (respectively) in men and 8.25, 15.69, 37.33, and 24.21 mm (respectively) in women.
Conclusions: A safe zone of dissection for midface augmentation has been identified, which differs from previous findings. Awareness of this zone may help clinicians locate the IOF and avoid injury to the nerve.

Keywords

midface augmentation, alloplastic facial implants, safe zone, infraorbital nerve, anatomic landmarks, nerve block, paresthesia

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Midface augmentation with alloplastic implants is a common cosmetic procedure; approximately 8800 cheek implant procedures were performed in 2009.[1] It can also be used as an adjunct to orthognathic and reconstructive surgery. Placement of malar, submalar, or paranasal implants requires intimate knowledge of the anatomy of the midface and the infraorbital foramen (IOF). Damage to the infraorbital nerve is associated with significant morbidity such as numbness of the upper lip, nasal sidewall, lower lid, and midface of the affected side.[2] It would be difficult to accurately estimate the incidence of postimplantation hypoesthesia,[3,4] and it is likely that such injuries are underreported in the aesthetic surgery literature. In one study of secondary malar implant surgery, 23% of patients who sought revision surgery complained of dysesthesia following the initial implant procedure.[5]

In an effort to prevent these complications, most surgeons rely on experience to identify the infraorbital nerve. Several attempts have been made to identify the IOF based on soft-tissue landmarks.[2,6] The purpose of this study is to define a safe zone of dissection in the subperiosteal plane based on bony and dental anatomic landmarks (Figure 1), which will preclude injury to the infraorbital nerve. Given our routine use of transconjuctival and intraoral incisions

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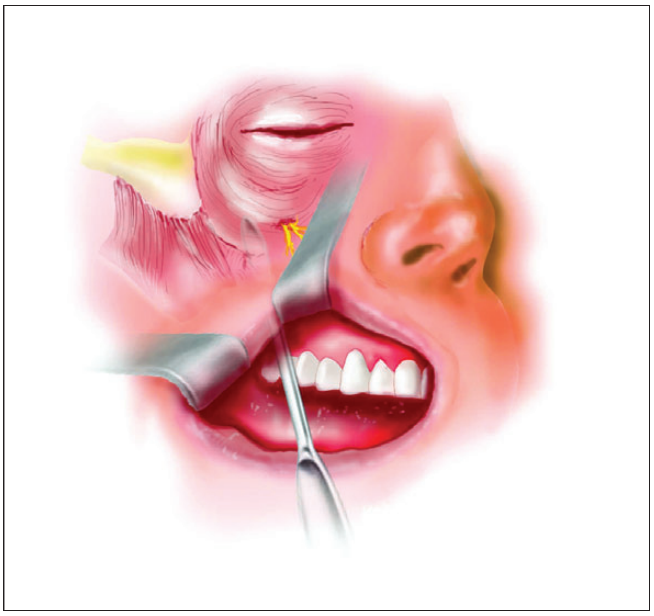

Figure 1. Illustration of an intraoral approach demonstrates the difficulty in identifying the infraorbital foramen in the absence of proper anatomic landmarks.

in midface augmentation, anatomic landmarks were chosen based on a bidirectional approach.[5,7-9]

METHODS

Forty-four spiral computed tomography (CT) scans of adult hemifaces were reviewed. We randomly selected the 44 patients (22 women and 22 men), with the aid of the Radiology Department, from the entire pool of patients that fulfilled our inclusion criteria. These patients had undergone CT scans for various medical reasons, in some cases to rule out craniomaxillofacial trauma. No patient in this series had undergone a previous procedure that would alter the measurements. Patients were also excluded from the study if they had sustained any midface fracture or had evidence of bony malformation or maxillary dental irregularity. In addition, patients younger than 18 years or older than 60 years were excluded.

All scans were performed using a standard exposure and patient-positioning protocol. Sagittal, axial, and coronal views, as well as 3-dimensional (3D) reconstruction models, were analyzed to obtain various distance measurements from the IOF.

The following bony and dental landmarks were identified for the IOF: the infraorbital rim, the cusps of the second premolar, the piriform aperture, and the lateral orbital rim. Volume Viewer software (version 10.3.67; GE Healthcare, Waukesha, Wisconsin) was used to obtain the measurements between the IOF and these landmarks (Figure 2). The Student *t* test was used to analyze the differences between men and women for each landmark.

RESULTS

Of the 44 hemifaces included in the study, 22 were from men and 22 were from women. The mean patient age was 31 years (range, 18-45 years). The location of the IOF correlated most frequently with the second premolar on a vertical axis. The average distance between the IOF and the infraorbital rim (IOR), the piriform aperture, the tip of the second premolar cusps, and the lateral orbital rim was approximately 8.61, 17.43, 41.81, and 25.93 mm (respectively) in men and 8.25, 15.69, 37.33, and 24.21 (respectively) in women. The mean measurements and standard deviations (SD) for these anatomic landmarks are listed in Table 1. (Figure 3 shows representative values for a male patient.)

Significant differences were found between men and women for the following measurements: distance between IOF and the tip of the second premolar cusps ($P < .0001$), distance between IOF and piriform aperture ($P < .0001$), and distance between IOF and the lateral orbital rim ($P = .001$). However, the distance between the IOF and IOR did not differ significantly between sexes ($P = .051$).

DISCUSSION

To maximize results and minimize morbidity in midface augmentation, it is important to understand facial nerve anatomy and identify the IOF. The principal sensory nucleus of the trigeminal nerve lies in the dorsal pons. The trigeminal nerve exits the skull through the foramen rotundum, traverses through the pterygopalatine fossa, and enters the orbit through the inferior orbital fissure. It passes through the infraorbital groove and canal in the floor of the orbit. It then exits to the facial skeleton through the IOF. At its termination, the nerve lies deep within the levator labii superioris muscle and divides into several branches that innervate the nasal sidewall, the lower eyelid, and the upper lip.[10]

Many studies have been conducted in an effort to assist clinicians in locating the IOF for procedures such as trigeminal nerve blocks, orthognathic surgery, and reconstructive surgery.[11-19,25] Various soft-tissue and bony landmarks have been described for the IOF. These include the midpupil,[2] the nasal ala,[11] the cheilion (mouth corner),[11] the piriform aperture,[5,12,16,18,23,26] the inferior orbital rim,[11-19,25] the canine,[23] the first premolar,[11,27] and the second premolar.[2]

Inconsistencies in measurements exist among the previously published studies and between sexes (Tables 2-4). The majority of these studies were performed on dried skulls, photographs of dried skulls, or cadaveric specimens. Although the average age of the skeletal specimens was not recorded, it is likely that they were older than our patients. In most of those studies, the distances between the IOF and the anatomic landmarks were shorter than our measurements, perhaps because of age-related changes in the facial skeleton.

The clinical relevance of our study is the young age of our study group, which is usually the common denomina-

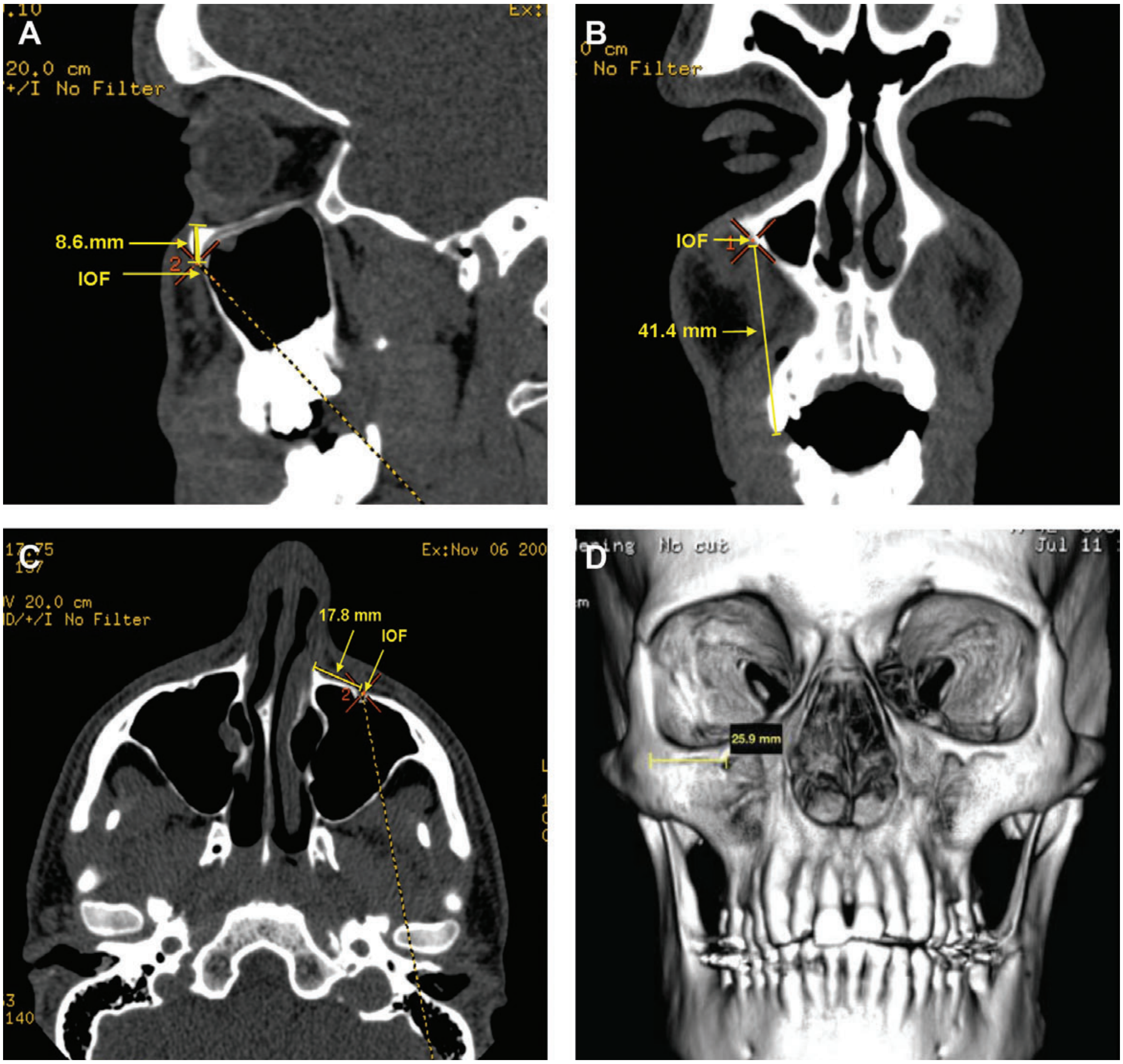

Figure 2. (A) Sagittal, (B) axial, (C) coronal, and (D) 3-dimensional views show distance measurements from the infraorbital foramen (IOF) to the anatomic landmarks.

tor among facial augmentation patients. The importance of facial skeletal aging in relation to midfacial augmentation has been demonstrated in several analyses of skeletal aging studies.[28-30] The dynamic process of facial bone loss involves a significant increase in orbital aperture,[29] decreased projection of the midface region,[28] and decreased facial height.[29] If these variables change with time, the measurements from studies of dried cadaveric specimens may not be as relevant as those from the present study.

Our surgical access to midface augmentation is usually obtained via the transconjuctival and intraoral approaches.[9,31,32] Transconjuctival and buccal incisions have been well tolerated by our patients. Moreover, they avoid external scarring and facilitate exposure of the zygomatic and maxillary bones.

Postseptal transconjuctival dissection enables the surgeon to define the periorbital anatomy up to and around the nerve. Soft tissues are elevated cephalad to the IOF and then dissection continues in a safe zone medial and lateral to the foramen. The intraoral approach enables identification of the lateral buttress. Dissection proceeds in the cephalolateral direction while the masseter insertion is preserved along the inferior border of the zygoma. Dissection medially is carried out with the goal of connecting

Table 1. Measurements From the IOF to Anatomic Landmarks

	Parameter	Mean, mm	SD, mm
Female	IOF-IOR	8.25	0.54
	IOF-PA	15.69	0.76
	IOF-2PM	37.33	1.58
	IOF-LOR	24.21	1.68
Male	IOF-IOR	8.61	0.64
	IOF-PA	17.43	1.19
	IOF-2PM	41.81	1.07
	IOF-LOR	25.93	1.59

Abbreviations: IOF, infraorbital foramen; IOR, inferior orbital rim; PA, piriform aperture; 2PM, second premolar; LOR, lateral orbital rim; SD, standard deviation.

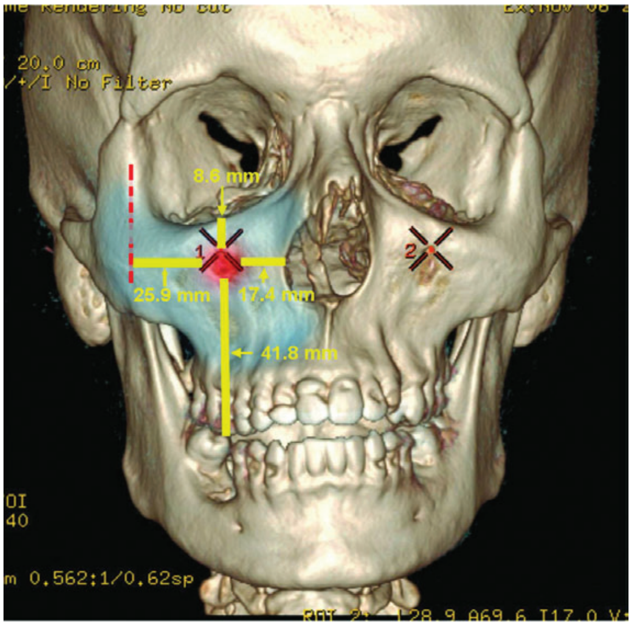

Figure 3. This 3-dimensional model of the skull of a 24-year-old man shows representative measurements from the infraorbital foramen to the anatomic landmarks. Blue shading denotes the safe zone; red shading denotes the danger zone.

the previously elevated tissues through the lower-lid approach and around the predicted location of the IOF, based on known anatomic landmarks.

In the absence of proper bony landmarks, it can be difficult (particularly for novice surgeons) to accurately locate the IOF and thus prevent injury to the infraorbital nerve. Dissection in the subperiosteal plane can be even more challenging without soft-tissue landmarks (Figure 1).

Table 2. Comparison of Measurements From the IOF to IOR

Study	Specimen	IOF-IOR, mm	SD, mm
Hindy and Abdel-Raouf[16]	Skulls and cadavers	6.10	NA
Chrcanovic et al[26]	Skulls	6.35 (f)	1.67 (f)
		6.63 (m)	1.75 (m)
Singh[18]	Skulls	6.16	1.80
Macedo and Cabrini[12]	Skulls	6.37	1.69
Cutright et al[17]	Cadavers	6.4	0.30
		5.8	0.30
Boopathi et al[19]	Skulls	6.57	1.70
Karakas et al[14]	Skulls	6.70	NA
Elias et al[20]	Skulls	6.71	1.70
Esper et al[21]	Skulls	6.80	NA
Gupta[22]	Skulls	7.0	1.6
Kazkayasi et al[23]	Skulls and x-rays	7.19	1.39
Aziz et al[11]	Cadavers	7.8 (f)	1.60 (f)
		8.5 (m)	2.2 (m)
Agthong et al[24]	Skulls	7.9	0.02
Canan et al[13]	Cadavers	8.30 (f)	NA
		10.90 (m)	NA
Chung et al[15]	Skull photographs	8.6	NA
Apinhasmit et al[25]	Skulls	9.23	NA
Present study	Spiral CT scans	8.25 (f)	0.54 (f)
		8.61 (m)	0.64 (m)

Abbreviations: CT, computed tomography; f, female; IOF, infraorbital foramen; IOR, inferior orbital rim; m, male; NA, not applicable; SD, standard deviation.

To maximize visualization of the bony surface anatomy, we recommend using high magnification, proper lighting, and effective hemostasis. The use of appropriate dental and skeletal landmarks also can be helpful when operating via small incisions through the lower eyelid or the oral mucosa.

In some patients, the piriform aperture may not be easily visualized during surgery. Therefore, we recommend that a safe dissection technique be employed in addition to reliance on the anatomic landmarks. For example, when operating near the IOF, dissection should always proceed cautiously in the subperiosteal plane, with a periosteal elevator. The use of cautery can be unsafe and lead to inadvertent thermal injury or even transection of the nerve.

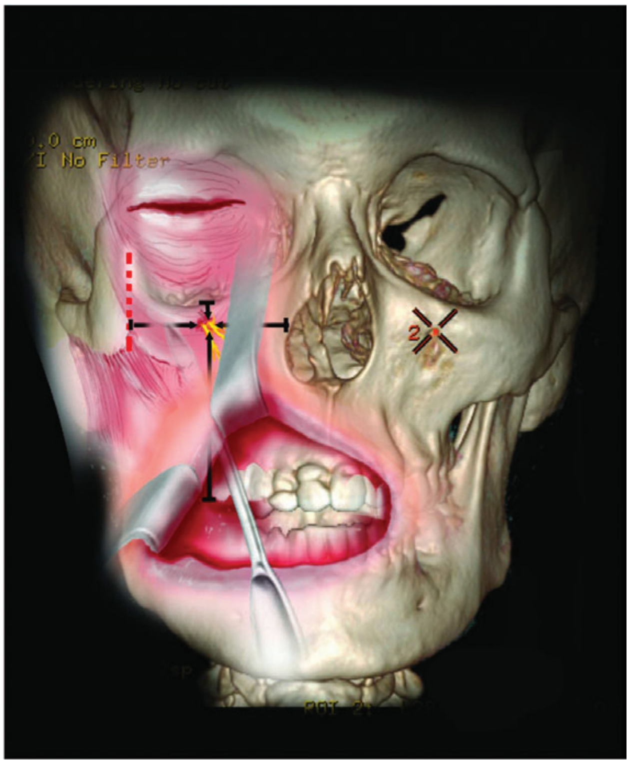

Figure 4. The ability to predict the location of the infraorbital foramen is based on bony and dental landmarks.

Table 3. Comparison of Measurements From the IOF to PA

Study	Specimen	IOF-PA, mm	SD, mm
Hindy and Abdel-Raouf[16]	Skulls and cadavers	17.23	NA
Chrcanovic et al[26]	Skulls	15.44 (f)	1.79 (f)
		14.37 (m)	2.04 (m)
Singh[18]	Skulls	15.56	2.60
Macedo et al[12]	Skulls	17.67	1.95
Kazkayasi et al[23]	Skulls and x-rays	14.70	NA
Present study	CT scans	15.69 (f)	0.76 (f)
		17.43 (m)	1.19 (m)

Abbreviations: CT, computed tomography; f, female; IOF, infraorbital foramen; m, male; NA, not applicable; PA, piriform aperture; SD, standard deviation.

It is important to measure from each anatomic landmark to the *outer* margin of the IOF to avoid entering a danger zone when dissection proceeds inferiorly through a transconjuctival incision or superiorly via a gingivobuccal sulcus incision (Figure 4). Moreover, when determining an appropriate zone of safety, it is essential to consider the differences between men and women (Table 1).

Table 4. Comparison of Measurements From the IOF to Dental Anatomic Landmarks

Study	Specimen	IOF-Ct, mm	SD, mm	IOF-1PM, mm	SD, mm	IOF-2PM, mm	SD, mm
Kazkayasi et al[23]	Skulls and x-rays	33.94	3.15	NA	NA	NA	NA
Brandão et al[27]	Skulls	NA	NA	33.4	5.2	NA	NA
Present study	CT scans	NA	NA	NA	NA	37.33 (f)	1.58 (f)
						41.81 (m)	1.07 (m)

Abbreviations: f, female; IOF, infraorbital foramen; Ct, canine tooth (lateral process); CT, computed tomography; m, male; NA, not applicable; 1PM, first premolar (alveolus top); 2PM, second premolar (top of cusps); SD, standard deviation.

CONCLUSIONS

Reliable anatomic landmarks exist for determining a safe zone of dissection in the midface. These include the infraorbital rim, the piriform aperture, the tip of the second premolar cusps, and the lateral orbital rim. Using these landmarks, which are appropriate for men as well as women, may minimize morbidity in reconstructive and aesthetic surgery or during nerve-block procedures.

Disclosures

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