Published in final edited form as:

J Craniofac Surg. 2018 March ; 29(2): 523–527. doi:10.1097/SCS.00000000000004186.

The infraorbital foramen is located midway between the nasospinale and jugale: Considerations for infraorbital nerve block and maxillofacial surgery

Matthew J. Zdilla^{1,2,*}, Aaron W. Koons¹, Michelle L. Russell¹, Kelsey R. Mangus¹, and Kaitlyn N. Bliss¹

¹Department of Natural Sciences and Mathematics, West Liberty University, West Liberty, West Virginia, 26074

²Department of Graduate Health Sciences, West Liberty University, West Liberty, West Virginia, 26074

Abstract

Identification of the infraorbital foramen is important in infraorbital nerve block and the prevention of iatrogenic injury of the infraorbital nerve in maxillofacial surgeries. This study assessed the location of 887 infraorbital foramina from 518 adult crania of varied sex and population. The study assessed the midpoint of a line segment spanning from nasospinale to jugale (NS-J) relative to the infraorbital foramen. The mean distance of the NS-J midpoint from the infraorbital foramen was 2.1 ± 1.9 mm (Mean $\pm$ SD) with a mode of 0 mm (266:887; 30%). The NS-J midpoint was located in the same plane or inferior to the infraorbital foramen in 98.4% of sides (873:887). There were no significant differences between sexes, populations, or sides with regard to the NS-J midpoint to infraorbital foramen distance. The NS-J midpoint can be used to locate the infraorbital foramen in both females and males of varied populations regardless of craniofacial diversity. The results of this study will aid in infraorbital nerve block procedures and maxillofacial surgery.

Keywords

infraorbital foramen; infraorbital nerve; nerve block; maxillofacial surgery

Introduction

Locating the infraorbital foramen (IOF) is an important step in infraorbital nerve block and radiofrequency neurotomy of the infraorbital nerve.¹ Also, the identification of the IOF is important for the prevention of iatrogenic injury of the infraorbital nerve in maxillofacial surgeries.^{2–7}

*Correspondence to: Matthew J. Zdilla, D.C., Associate Professor of Biology & Physician Assistant Studies, West Liberty University, Department of Natural Sciences and Mathematics, CSC 139; P.O. Box 295, West Liberty, WV (USA) 26074. Tel.: +1 304-336-8631; Fax: +1 304-336-8266; mzdilla@westliberty.edu.

In order to aid in the localization of the IOF, several studies have determined distances between the foramen and nearby bony landmarks, soft tissue structures, and anatomical planes. Typically, studies have utilized the lateral margin of the piriform aperture, the inferior rim of the orbit, and the median plane of the skull as locations from which to measure the distance to the IOF. However, other landmarks have been utilized as reference points, including the maxillary alveolar border, medial palpebral commissure,^{8,9} lateral palpebral commissure,⁹ dacryon, ectoconchion, nasal ala,^{8,10} anterior nasal spine, cheilion, zygomatico-maxillary suture,^{11,12} frontomaxillary suture, and supraorbital foramen.^{13–15}

The location of the IOF has also been studied in relation to the maxillary teeth. Some have noted that the position of the IOF is usually in the same vertical plane as the 1st premolar.¹⁶ Others have documented that the IOF is more often in the same vertical plane as the 2nd premolar.^{17–20} However, the IOF may be located vertical to the range spanning from the canine to the 1st molar.^{5,19}

Among the aforementioned IOF localization methods, many have revealed significant differences between varied populations. Statistically significant differences between male and female morphometric measurements regarding the location of the IOF have been reported.^{10,11,13,15,21–25} Also, significant differences among populations have also been reported.^{11,22} Furthermore, reports have documented bilateral asymmetry of IOF locations.^{25–28}

Locating the IOF is important in myriad operative procedures. A variety of studies have provided distances from bony and soft tissue landmarks in order to improve the localization of the foramen; however, measurements have revealed variability between sexes, populations, and sides of the face. Therefore, a standardized method to accurately locate the IOF independent of sex, population, or laterality, has yet to be identified. Based upon observations of the facial skeletal structure, this study is constructed upon the hypothesis that the IOF may be located midway between nasospinale (NS) and jugale (J) regardless of sex, population, or laterality. The aim of the report is to assess the location of the IOF relative to NS-J midpoint in varied populations to determine if the NS-J midpoint may serve as a reliable indicator of the IOF location regardless of sex, population, or laterality.

Materials and Methods

This study analyzed digital images of crania from the Online Research Scan Archive (ORSA), formerly known as the Penn Cranial CT Database. The images were of the crania from the Samuel George Morton Collection,^{29–31} housed and curated at the University of Pennsylvania Museum of Archaeology and Anthropology. Crania from individuals in their first or second decade were excluded from the study. A total of 518 adult crania (i.e., 3rd decade and older at death) were analyzed. The 518 cranial images were screened by the authors for bone damage or poor image quality. After screening, a total of 887 foramina (442 left-sided and 445 right-sided) were ultimately included in the morphometric analysis. There were a total of 374 female foramina and 489 male foramina. With regard to population, there were 56 different classifiers included in the study (e.g., Celtic, Chinese, Laplander, Spaniard, Swedish, Tahitian, etc.).

The image analysis was performed with ImageJ software.^{32,33} Line segments were drawn from the NS to the J with the line tool, which automatically identifies a midpoint. The landmarks used in this study can be seen in Figure 1. The anatomical direction and distance of the midpoint relative to the IOF were recorded. Additionally, the angle formed between the sagittal plane and the line segment spanning between NS and J was recorded with ImageJ software. The length of the NS-J line segment was also recorded.

With regard to inferential statistical analysis, Pearson correlation was performed between NS-J midpoint to IOF distance and NS-J angle. Likewise, Pearson correlation was performed between NS-J midpoint to IOF distance and NS-J line segment length. An unpaired t-test was performed to analyze differences between sexes. Of all the populations included in the study, crania from individuals of African descent (which Morton/Meigs classified as African or Negro), Egyptians (not included in Morton/Meigs classification as African), and Peruvians were selected for intra-population comparison. Other populations were composed of too few crania to be adequately representative. The African, Egyptian, and Peruvian samples comprised subtotals of 109, 135, and 265 foramina, respectively. A one-way ANOVA was performed to analyze differences among the African, Egyptian, and Peruvian crania. A paired t-test was performed to analyze differences of NS-J midpoint distance from the IOF between left and right sides.

Results

The mean distance from the NS-J midpoint and the infraorbital foramen was 2.1 ± 1.9 mm (Mean $\pm$ SD) with a mode of 0 mm. A relative frequency distribution can be found in Figure 2. The NS-J midpoint was, most often located directly inferior to the IOF (33.15%). The NS-J midpoint was directly upon the IOF in 29.99% of measurements (Fig. 3). The midpoint was located at or below the level of the IOF in 98.42% (873:887) of measurements (Fig. 4).

The average angle between the NS-J line segment and the sagittal plane was $65.65 \pm 4.24^\circ$ (Mean $\pm$ SD). The minimum and maximum angles were 54.21° and 79.99° , respectively (Fig. 5). There was a very weak positive correlation between the angle of the line segment between the NS and J and the distance of the NS-J midpoint from the IOF ($r=0.1$; $p=0.0018$).

The average length between the NS and J was 75.12 ± 6.60 mm (Mean $\pm$ SD). The minimum and maximum distance were 58.89 mm and 99.08 mm, respectively. There was no correlation between the length of the line segment between the NS and J and the distance of the NS-J midpoint from the IOF ($r=0.02$; $p=0.5442$).

Comparison between Sexes

The mean NS-J distance from the IOF was 2.12 ± 1.91 mm among females and 2.17 ± 1.93 mm among males. There was no statistically significant difference between sexes with regard to NS-J midpoint distance from the IOF ($t=0.408(861)$; $p=0.68$). Relative frequency distribution can be found in Figure 6.

Comparison between Populations

One way ANOVA revealed no statistically significant difference among NS-J midpoint distances from the IOF between African, Egyptian and Peruvian crania ($F(2,506)=2.11$; $p=0.1224$).

Comparison between Sides

Regarding side, the mean for the distance from the NS-J midpoint to the IOF was $2.09\pm1.87\text{mm}$ and $2.14\pm1.97\text{mm}$ on the left and right sides, respectively. A paired t-test revealed no statistically significant difference between sides with regard to NS-J midpoint distance from the IOF ($t=0.306(424)$; $p=0.76$). Relative frequency distribution can be found in Figure 7.

Discussion

Identification of the IOF is important in the management of maxillofacial trauma, facial plastic surgery, and orofacial anesthesia. Many studies have provided metrics regarding the location of the IOF relative to various bony structures, soft tissue landmarks, and teeth; however, many of these studies have revealed differences between sexes, populations, and sides of the face. This study is unique in that it identifies a simple method to locate the IOF regardless of sex, population, or side of the face.

The results of this study noted that the average NS-J midpoint distance from the IOF was less than 2mm in any specific direction (Table 1; Fig. 4). The NS-J midpoint was located directly upon the IOF in 29.99% of measurements. When it was not located directly on the IOF, it was almost always located at the same plane or below the level of the IOF. With regard to infraorbital nerve block, the IOF is approached from the inferior in both percutaneous and intraoral methods.³⁵ If the NS-J midpoint were utilized as a target and approached from the inferior, it would be unlikely to overshoot the infraorbital nerve as it exits the IOF (the infraorbital ridge would also limit needle advancement). Rather, the NS-J midpoint target would likely overlie the infraorbital nerve as it emerges from the IOF either directly at the IOF or just inferior to the IOF.

Studies have revealed differences in IOF location between sexes, populations, and sides. The method described in this study noted no differences between sexes or populations and, therefore, would not be useful in the differentiation of sexes or populations. However, this method may be generally useful in the reconstruction of a cranium with maxillary or zygomatic damage. For example, if the NS and IOF are present, the J would be generally located in line with the NS and IOF – an additional length away from the IOF equal to that of the NS to IOF distance. The same concept would apply for identifying the general location of an absent NS from a present J and IOF.

The study revealed a very small significant correlation between the angle formed by the NS-J line segment and the NS-J midpoint distance from the IOF ($r=0.1$; $p=0.0018$). The small degree of correlation is impractical to consider in a clinical setting. Moreover, the length of the NS-J line segment was not correlated with NS-J midpoint distance from the IOF. These statistics support the notion that, even in craniofacially diverse populations (i.e., different

sexes and populations), the NS-J midpoint may serve as a viable target for locating the IOF and infraorbital nerve.

This study did not account for the variable accessory infraorbital foramen.¹⁹ Further, this report did not take the size, shape, and orientation of the IOF into account – all of which have been reported to vary.^{10,19,36} Because the orientation of the foramen varies, in addition to differences in the prominence of the infraorbital ridge, shadow-effect may have served as a potential source of error in this report. Also, the reference scale utilized in the calibration of digital imaging software was located beyond the plane that was being measured. Therefore, distance measurements in this report likely err on the side of being longer than they actually are. For example, the average distance of the NS-J midpoint from the IOF was reported as 2.1mm; however, it is likely less than 2.1mm.

In conclusion, this report identifies a novel method to identify the location of the IOF and infraorbital nerve using easy-to-palpate superficial bony landmarks. Also the NS-J midpoint may serve as a method of identifying the IOF and, therefore, the infraorbital nerve, regardless of sex, population, or side of the face.

Acknowledgments

The work was made possible through grant funding from the WV Research Challenge Fund [HEPC.dsr.14.13] and [HEPC.dsr.17.06] which supported a summer undergraduate research program in which the authors AWK, MLR, KRM, and KNB participated. The work was also made possible through funding from the West Virginia IDeA Network for Biomedical Research Excellence [P20GM103434], and NIH-NIAID [5K22AI087703]. The authors also acknowledge the University of Pennsylvania Museum of Archaeology and Anthropology, the Open Research Scan Archive at the University of Pennsylvania, as well as P. Thomas Schoenemann and Janet Monge for the expansion and improvement of the Penn Cranial CT Database [NSF Award Number 0447271]. The authors declare no conflicts of interest.

References

1. Rahman M, Richter EO, Osawa S, et al. Anatomic study of the infraorbital foramen for radiofrequency neurotomy of the infraorbital nerve. *Neurosurgery*. 2013; 64:423–427.
2. Meyer M, Moss AL, Cullen KW. Infraorbital nerve palsy after rhinoplasty. *J Craniomaxillofac Surg*. 1990; 18:173–174. [PubMed: 2358507]
3. de Mol van Otterloo JJ, Tuinzing DB, Greebe RB, et al. Intra- and early postoperative complications of the Le Fort I osteotomy. A retrospective study on 410 cases. *J Craniomaxillofac Surg*. 1991; 19:217–222. [PubMed: 1894740]
4. Kersey JP, Beigi B. Infraorbital nerve decompression for infraorbital neuralgia following orbital fracture. *British Oculoplastic Surg Soc*. 1999; 10:24–27.
5. Kazkayasi M, Ergin A, Ersoy M, et al. Certain anatomical relations and the precise morphometry of the infraorbital foramen--canal and groove: an anatomical and cephalometric study. *Laryngoscope*. 2001; 111:609–614. [PubMed: 11359128]
6. 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. [PubMed: 23220876]
7. Kotrashetti SM, Kale TP, Bhandage S, et al. Infraorbital nerve transpositioning into orbital floor: a modified technique to minimize nerve injury following zygomaticomaxillary complex fractures. *J Korean Assoc Oral Maxillofac Surg*. 2015; 41:74–77. [PubMed: 25922818]
8. Zheng WX, Guo JL, Song BX, et al. Location of the supraorbital and infraorbital foramen with references to the soft tissue landmarks in a Chinese population. *J Craniofac Surg*. 2012; 23:1154–1155. [PubMed: 22801112]

9. Ercikti N, Apaydin N, Kirici Y. Location of the infraorbital foramen with reference to soft tissue landmarks. *Surg Radiol Anat.* 2017; 39:11–15. [PubMed: 27146295]
10. Takahashi Y, Kakizaki H, Nakano T. Infraorbital foramen: horizontal location in relation to ala nasi. *Ophthal Plast Reconstr Surg.* 2011; 27:295–297.
11. Cutright B, Quillopa N, Schubert W. An anthropometric analysis of the key foramina for maxillofacial surgery. *J Oral Maxillofac Surg.* 2003; 61:354–357. [PubMed: 12618976]
12. Gupta T. Localization of important facial foramina encountered in maxillo-facial surgery. *Clin Anat.* 2008; 21:633–640. [PubMed: 18773483]
13. Agthong S, Huanmanop T, Chentanez V. Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. *J Oral Maxillofac Surg.* 2005; 63:800–804. [PubMed: 15944977]
14. Liu DN, Guo JL, Luo Q, et al. Location of supraorbital foramen/notch and infraorbital foramen with reference to soft- and hard-tissue landmarks. *J Craniofac Surg.* 2011; 22:293–296. [PubMed: 21239922]
15. Lee T, Lee H, Baek S. A three-dimensional computed tomographic measurement of the location of infraorbital foramen in East Asians. *J Craniofac Surg.* 2012; 23:1169–1173. [PubMed: 22801117]
16. Aziz SR, Marchena JM, Puran A. Anatomic characteristics of the infraorbital foramen: a cadaver study. *J Oral Maxillofac Surg.* 2000; 58:992–996. [PubMed: 10981979]
17. Hindy AM, Abdel-Raouf F. A study of infraorbital foramen, canal and nerve in adult Egyptians. *Egypt Dent J.* 1993; 39:573–580. [PubMed: 9588126]
18. Apinhasmit W, Chompoopong S, Methathrathip D, et al. Supraorbital Notch/Foramen, Infraorbital Foramen and Mental Foramen in Thais: anthropometric measurements and surgical relevance. *J Med Assoc Thai.* 2006; 89:675–682. [PubMed: 16756055]
19. Aggarwal A, Kaur H, Gupta T, et al. Anatomical study of the infraorbital foramen: A basis for successful infraorbital nerve block. *Clin Anat.* 2015; 28:753–760. [PubMed: 26119635]
20. Nanayakkara D, Peiris R, Mannapperuma N, et al. Morphometric Analysis of the Infraorbital Foramen: The Clinical Relevance. *Anat Res Int.* 2016; 2016:1–8.
21. Canan S, Asim OM, Okan B, et al. Anatomic variations of the infraorbital foramen. *Ann Plast Surg.* 1999; 43:613–617. [PubMed: 10597821]
22. Ilayperuma I, Nanayakkara G, Palahepitiya N. Morphometric analysis of the infraorbital foramen in adult Sri Lankan skulls. *Int J Morphol.* 2010; 28:777–782.
23. Chrcanovic BR, Abreu MH, Custódio AL. A morphometric analysis of supraorbital and infraorbital foramina relative to surgical landmarks. *Surg Radiol Anat.* 2011; 33:329–335. [PubMed: 20625730]
24. Joseph CC, Soman MA, Jacob M, et al. Morphometric Variations In Infra Orbital Foramen of Dry Adult Human South Indian Skulls with Its Surgical and Anaesthetic Significance. *IJHSR.* 2015; 5:130–134.
25. Cisneiros de Oliveira LC, Silveira MP, de Almeida Júnior E, et al. Morphometric study on the infraorbital foramen in relation to sex and side of the cranium in northeastern Brazil. *Anat Cell Biol.* 2016; 49:73–77. [PubMed: 27051570]
26. Macedo VC, Cabrini RR, Faig-Leite H. Infraorbital foramen location in dry human skulls. *Braz J Morphol Sci.* 2009; 26:35–38.
27. Ekambaram G, Shaik RA, Salmani D, et al. A genderwise study on the morphometry of infraorbital foramen and its laterally in dry adult skulls oh south Indian population. *Int J Med Sci Public Health.* 2014; 3:546–548.
28. Ukoha UU, Umeasalugo KE, Udemezue OO, et al. Anthropometric measurement of infraorbital foramen in south-east and south-south Nigeria. *Natl J Med Res.* 2014; 4:225–227.
29. Morton, SG. To which is prefixed an essay on the varieties of the human species. Philadelphia: Dobson; 1839. *Crania Americana; or, A comparative view of the skulls of various aboriginal nations of North and South America.*
30. Morton, SG. Catalogue of Skulls of Man and the Inferior Animals in the Collection of Samuel George Morton. 3. Philadelphia: Merrihew & Thompson; 1849.

31. Meigs, JA. Catalogue of human crania, in the collection of the Academy of natural sciences of Philadelphia: Based upon the third edition of Dr. Morton's "Catalogue of Skulls," &c. Philadelphia: JB Lippincott & Co; 1857.
32. Abramoff MD, Magalhaes PJ, Ram SJ. Image Processing with ImageJ. Biophoton Int. 2004; 11:36–42.
33. Schneider CA, Rasband WS, Eliceiri KW. NIH Image to ImageJ: 25 years of image analysis. Nat Methods. 2012; 9:671–675. [PubMed: 22930834]
35. Lynch MT, Syverud SA, Schwab RA, et al. Comparison of intraoral and percutaneous approaches for infraorbital nerve block. Acad Emerg Med. 1994; 1:514–519. [PubMed: 7600397]
36. Rai AR, Rai R, Vadgaonkar R, et al. Anatomical and morphometric analysis of accessory infraorbital foramen. J Craniofac Surg. 2013; 24:2124–2126. [PubMed: 24220421]

Figure 1.

Anterior view of a cranium labeled with the landmarks utilized in this study. A translucent line segment spans between the nasospinale and jugale (**NS**: nasospinale; **IOF**: infraorbital foramen; **J**: jugale).

Figure 2.

Relative frequency distribution of nasospinale to jugale midpoint distance from the infraorbital foramen. The most common frequency was at the 0mm bin center (30.7%). The 1mm, 2mm, and 3mm bin center frequencies were 11.2%, 17.9%, and 16.7% respectively.

Figure 3.
Percentage of relative locations of NS-J midpoints from IOF.

Figure 4.

Radar plot of average nasospinale-to-jugale midpoint distances (mm) from the infraorbital foramen according to anatomical directions relative to the foramen (mean+SD). This figure corresponds to the descriptive statistics found in Table 1.

Figure 5.

Two nasospinale-to-jugale lines are juxtaposed to illustrate the varied angles formed by the NS-J line segment. The range between the minimum and maximum angles was 25.78° . (**A**: NS-J line segment oriented relatively more vertical than that of **B**, which is relatively horizontal).

Figure 6.

Relative frequency distribution of nasospinale to jugale midpoint distance from the infraorbital foramen in females and males. The most common frequency in both left and right sides was at the 0mm bin center (30.5% and 29.2%, respectively). The 1mm, 2mm, and 3mm bin center frequencies each varied less than one percent or less between sides.

Figure 7.

Relative frequency distribution of nasospinale to jugale midpoint distance from the infraorbital foramen in left and right sides. The most common frequency in both left and right sides was at the 0mm bin center (30.1% and 31.2%, respectively). The 1mm, 2mm, and 3mm bin center frequencies each varied less than two percent between sides.

Table 1

Average distances of the nasospinale-to-jugale midpoint from the infraorbital foramen separated by the location of the midpoint relative to the foramen.

Direction Relative to the IOF	Number of measurements	Mean distance from IOF (mm)*	±SD	±SEM	95% CI	
					Lower	Upper
Superior	274	0.06	0.47	0.028	0.005226	0.1166
Superolateral	270	0.03	0.36	0.022	-0.009508	0.07692
Lateral	302	0.24	0.77	0.044	0.1552	0.3285
Inferolateral	431	1.12	1.72	0.083	0.9589	1.284
Inferior	561	1.64	1.94	0.082	1.475	1.797
Inferomedial	561	0.81	1.67	0.088	0.635	0.9827
Medial	297	0.29	0.98	0.057	0.175	0.3998
Superomedial	271	0.04	0.34	0.021	0.005272	0.07553

* : If the nasospinale-to-jugale midpoint fell directly upon the infraorbital foramen, a distance of 0mm was assigned to the measurement. All means presented in this table included the 0mm measurements in their calculations.