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Infraorbital foramen location in the pediatric population: A guide for infraorbital nerve block

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Abstract

Background—Infraorbital nerve blocks are often performed for the management of postoperative pain associated with cleft lip correction. Infraorbital nerve block procedures depend on the identification of the infraorbital foramen; however, there is little information regarding the infraorbital foramen location in the pediatric population.

Aim—Identify the location of the infraorbital foramen in the pediatric population relative to a midpoint between the nasospinale and jugale.

Methods—The study assessed the location of 152 infraorbital foramina relative to a midpoint between the nasospinale and jugale on dry crania. Crania were from individuals ranging in age-at-death from six-months-fetal to 18 years. The population was subdivided into fetal/infant (6 months fetal age - <2 years), child (2 years - <12 years), and adolescent (12 years - 18 years) groups for comparison.

Results—The average distance of the infraorbital foramen from the nasospinale-to-jugale midpoint was $1.55 \pm 0.78\text{mm}$ (Mean $\pm$ SD) in the fetal/infant group, $0.80 \pm 0.91\text{mm}$ in the child group, and $1.31 \pm 1.68\text{mm}$ in the adolescent group. Further, infraorbital foramina tended to be located medial to the nasospinale-to-jugale midpoint in the fetal/infant population, directly upon or superomedial to the nasospinale-to-jugale midpoint in the child population, and directly upon or superior/superolateral to the nasospinale-to-jugale midpoint in the adolescent population.

Conclusions—The infraorbital foramen was located within two millimeters, on average, from the nasospinale-to-jugale midpoint regardless of age group. Therefore, the nasospinale-to-jugale midpoint may serve as useful means of identifying the location of the infraorbital foramen in the pediatric population and aid in optimizing infraorbital nerve block procedures. The information in this report is valuable in general, but may be particularly useful in developing countries where

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there is a lack of ultrasound training and availability for health care providers; or places where infraorbital nerve block may be the sole anesthetic modality for cleft lip surgery, even among adolescent patients.

Keywords

anesthesia; cleft lip; cleft palate; facial pain; maxilla; maxillofacial development

Introduction

Infraorbital nerve blocks (IONB) are often performed in the pediatric population for the management of postoperative pain associated with cleft lip surgery.^{1–5} To perform IONB, whether by the transcutaneous or intraoral approach, the location of the infraorbital foramen (IOF) must first be recognized. Recognizing the IOF location may help optimize anesthesia and aid in the prevention of iatrogenic injuries including maxillary sinus puncture and globe penetration.^{6–8}

Recognition of the IOF by ultrasonography (US) is feasible, though little study regarding the use of US in the identification of the IOF in the pediatric population has been performed.⁹ Moreover, in developing countries where IONB may be to sole anesthetic modality for lip surgery, there is a lack of US training for health care providers or a lack of US availability altogether.^{4,10,11} Therefore, investigating novel methods of locating the IOF independent of US guidance is warranted.

Several anatomical studies regarding the location of the IOF have been performed in the adult population;¹² however, only a few have examined the location of the IOF in the pediatric population.^{13–15} Because of differences in the facial structure between adult and pediatric populations, many of the methods utilized to identify the IOF in adults, such as localizing the IOF relative to the maxillary teeth, do not translate well to the pediatric population— not only due to of the lack of tooth eruption among very young patients, but also because common pediatric pathologies such as cleft lip with concomitant cleft palate are, by their nature, disrupting the normal development of the alveolar ridge.

A recent study, analyzing 887 infraorbital foramina from 518 craniofacially diverse adult crania, identified a novel means of locating the infraorbital foramen by using the nasospinale (NS) and jugale (J) cranial landmarks as reference points.¹² The study revealed that the IOF was located directly at the midpoint between the NS and J landmarks in approximately one-third of sides and, likewise, directly superior to the midpoint in approximately one-third of sides. On average, the midpoint was located 2.1mm from the IOF (Mean) having a mode of 0mm (266:887; 30%). Moreover, the midpoint was almost always located at or below the level of the IOF (873:887; 98.4%).¹² While the aforementioned method of locating the IOF may have clinical promise among adults, it has not been investigated in the pediatric population.

Locating the IOF is important for IONB; yet, there is a paucity of anatomical study regarding the IOF location in the pediatric population. Therefore, the aim of this study is to

describe the location of the IOF in the fetal/infant, child, and adolescent populations with regard to the NS-J midpoint.

Materials and Methods

The study sampled digital images of human crania from the Samuel George Morton Collection, housed and curated at the University of Pennsylvania Museum of Archaeology and Anthropology. Analysis was limited to crania ranging in age from six months fetal age at death to 18 years of age at death. Age groupings were assigned to the crania as follows: A fetal/infant group included crania ranging in age from six months fetal age to age to two years of age. A child group included crania from individuals between the age of two years and 12 years. An adolescent group included crania from individuals between the age of 12 and 18 years. A total of 152 foramina were assessed (Fetal/Infant: n=16; Child: n=49; Adolescent: n=87).

The method of location was based upon the observation that the IOF was located midway between the nasospinale (NS) and jugale (J) (Figure 1).¹² ImageJ software was used for image analysis.¹⁶ The distance between the midpoint of the line segment spanning from NS to J and the IOF was measured. The anatomical direction of the midpoint relative to the IOF was recorded. Additionally, the length of the NS-J line segment and the angle formed between the sagittal plane and the line segment were measured to assess the diversity of cranial size and shape among the population.

With regard to descriptive statistics, frequency distribution of the distances from the IOF to the NS-J midpoints were calculated. Further, the NS-J midpoint to IOF distances, relative to location (e.g., superior, inferior, lateral, etc.), were graphically represented through radar plots and a heat map in order to visualize trends across age groups.

Results

A summary of average distances of the NS-J midpoint to the IOF in fetal/infant, child, and adolescent populations can be found in Table 1. With regard to frequency distribution, the NS-J midpoint was most often located approximately 2mm away from the IOF in fetuses/infants (43.75%) (Figure 2). The midpoint was most often located directly upon the IOF in children (48.98%) and adolescents (49.43%) (Figure 2).

In the fetal/infant population, the NS-J midpoint tended to be located lateral to the IOF (Figure 3). In the child population, the NS-J midpoint tended to be located either directly upon or inferolateral to the IOF (Figure 3). In the adolescent population, the midpoint was typically located directly upon or inferior/inferomedial to the IOF (Figure 3). A summary of average distances of the NS-J midpoint to the IOF based upon relative direction from the IOF can be found in Table 2. Side-by-side comparison of NS-J midpoint location relative to the IOF between age groups, reveals a migration of the midpoint from superolateral to inferomedial with advancing age (Figure 4).

Discussion

Infraorbital nerve blocks are commonly performed in the pediatric population, despite the paucity of research regarding the location of the IOF. Infraorbital nerve blocks are usually applied in management of postoperative pain associated with cleft lip surgery.^{1–5} Otherwise, IONB has been used in instances of endoscopic sinus surgery,¹⁷ nasal fracture,¹⁸ orbital floor fracture,¹⁹ and transsphenoidal hypophysectomy.²⁰ Potential pitfalls in IONB procedures include maxillary sinus puncture and globe penetration.^{6–8} In order to avoid pitfalls and optimize anesthesia, it is important to properly locate the IOF. This study presents a novel method of approximating the location of the IOF in the pediatric population by using the NS and J — two easily palpated bony landmarks.

Though dozens of studies have analyzed the IOF location among adults, only a few studies have specifically studied the location of the IOF in pediatric populations:^{13–15}

- Bösenberg and Kimble¹³ performed a study of 15 African neonate cadavers (30 sides) and noted that the IOF was located approximately halfway along a line drawn from the angle of the mouth to the midpoint of the palpebral fissure.
- Suresh et al¹⁴ performed a computed tomography study of 48 pediatric patients (mean age = 9.7 years; age range = 0.8–17.75 years) and noted an equation to locate the distance between the IOF and the midline given by $21.3 \text{ mm} + 0.5 \times \text{age (in years)}$.
- Lee et al¹⁵ analyzed a population of Korean children by three-dimensional reconstructed CT scans— 60 sides from an age group of 0–9 years and 60 sides from an age group of 10–19 years. Their methods utilized landmarks around the bony orbit to measure distances in the x and y dimensions (i.e., along axial and sagittal planes).

This study supplements the findings of the aforementioned reports. The study by Bösenberg and Kimble¹³ utilized the angle of the mouth as a landmark in neonates; however, IONB is typically performed in the infant population for post-operative pain resulting from cleft lip. These conditions inherently contribute to alteration of the mouth anatomy, thereby influencing the reference point utilized in the study by Bösenberg and Kimble.¹³ The same considerations must be thought of in the case of the present study, bearing in mind that orofacial clefts may influence nasal anatomy. A benefit of utilizing the NS, however, is that the landmark falls along the midline and may be approximated by referencing other midsagittal landmarks.

The study performed by Suresh et al¹⁴ provides the distance of the IOF from the midline as a mathematical function of age. As mentioned earlier, the midline should be considered a fairly reliable reference. The study of Suresh et al¹⁴ assessed the distance of the IOF from the midline in the horizontal plane, but did not assess the location of the IOF along the sagittal plane (i.e., superior/inferior). The present study assessed the location of the IOF with regard for both the sagittal and axial planes by using one oblique measurement. Further, utilizing the NS-J midpoint to locate the IOF would not require memory of a mathematical formula.

The average distances between the NS-J midpoint and the IOF were 1.55mm, 0.80mm, and 1.31mm from the fetal/infant, child, and adolescent populations, respectively. A recent study of adult crania, using the same methods as this study, noted a mean distance of between the NS-J midpoint and the IOF of 2.1mm with a mode of 0mm.¹² Therefore, determination of the NS-J midpoint for localizing the IOF appears to be a relatively consistent method from childhood through adulthood. However, when considering the values as ratios of facial size, one must consider that a 1.55mm distance upon the small face of an infant may be perceptually different than a 2.1mm distance upon the large face of an adult.

With regard to surface anatomy, the bony landmarks utilized in this study have little overlying soft tissue and, therefore, can be palpated. The nasospinale corresponds to the columella. The jugale can be identified by palpating along the superior aspect of the zygomatic arch. Further study should investigate how surrounding soft tissues might influence the identification of the nasospinale and jugale.

In conclusion, IONB procedures are commonly performed in the pediatric population despite a paucity of information regarding the location of the IOF. Ultrasonography has never been demonstrated as an improvement in safety nor efficacy relative to landmark methods for IONB procedures.²¹ Furthermore, even when assuming US efficacy in the pediatric population, there is still a lack of equipment and training worldwide, particularly in developing countries where IONB may be the sole anesthetic modality for lip surgery. This research concluded that the IOF was located within two millimeters, on average, from the NS-J midpoint regardless of age group. Therefore, the NS-J midpoint may serve as useful means of identifying the location of the IOF in the pediatric population. The method may aid in optimizing both intra- and extra-oral infraorbital nerve block procedures.

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Clinical Implications

What is already known

Infraorbital nerve blocks are performed despite insufficient data regarding the location of the infraorbital foramen in the pediatric population.

What this article adds

This article demonstrates a method of locating the infraorbital foramen that can improve nerve block procedures.

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Figure 1.

Anterior cranium of an eight-year-old child highlighting salient facial anatomy, including the nasospinale and jugale landmarks. **A:** The zygomatic bone (**GREEN**) with the frontal process of the zygomatic bone (**BLUE**) and the temporal process of the zygomatic bone (**RED**). The jugale landmark is located where the frontal and zygomatic processes meet. **B:** Zoomed view of the left-sided midface from Figure 1A above. The midpoint (**STAR**) of a line segment spanning from nasospinale (**NS**) to jugale (**J**), can be seen in proximity to the infraorbital foramen (**IOF**). The nasospinale is defined as the point of intersection of a line uniting the lowest points on the margin of each nasal opening with the midsagittal plane. The jugale is defined as the point at which the temporal and frontal processes of the zygomatic bone meet. The distance from the midpoint to the infraorbital foramen was measured in this study.

Figure 2.

Histograms of relative frequency, expressed as a percentage, of the nasospinale to jugale midpoint distance from the IOF (mm). **A:** The fetal and infant population had the greatest relative frequencies at bin centers of 2mm and 1mm (43.75% and 31.25%, respectively). Accordingly, this population had the largest mean NS-J midpoint to IOF distance of all the age groups at 1.55 ± 0.78 mm (Mean $\pm$ SD). **B:** Among children, 48.98% had a NS-J midpoint distance from the IOF at a bin center of 0mm, followed by 26.53% at a bin center of 1mm. **C:** The adolescent population had the greatest relative frequency of 49.43% at a bin center of 0mm. All other bin centers (i.e., 1mm – 8mm) had relative frequencies less than 14%.

Figure 3.

Heat map relating the relative frequency (expressed as a percentage) of the location of the nasospinale-to-jugale midpoint relative to the infraorbital foramen by age. During the fetal/ infant development, the NS-J midpoint is located lateral or superolateral to the IOF. During childhood, the midpoint tends to be located directly upon the IOF or lateral/inferolateral. In adolescence, the midpoint tends to be located directly upon the IOF or inferior/inferomedial to the foramen.

Figure 4.

Radar plots demonstrating average nasospinale-to-jugale midpoint distances (mm) from the infraorbital foramen according to anatomical directions relative to the foramen (mean+SD). The series of plots demonstrate that the relative location of the midpoint tends to migrate from lateral to inferior over time. **A:** infants between the age of six fetal months and two years; **B:** children between two years and twelve years and; **C:** adolescents between 12 and 18 years of age. This figure corresponds to the descriptive statistics found in Table 1.

Table 1

Descriptive statistics regarding distance (in millimeters) of the nasospinale-to-jugale midpoint from the infraorbital foramen in fetal/infant, child, and adolescent populations.

	Min	25%	Median	75%	Max	Mean	±SD	±SEM	95% CI	
									Lower	Upper
6 months fetal age - <2 years	0.00	1.13	1.67	2.00	2.70	1.55	0.78	0.19	1.13	1.96
2 years - <12 years	0.00	0.00	0.05	1.46	3.31	0.80	0.91	0.13	0.54	1.06
12 years - 18 years	0.00	0.00	0.62	2.32	7.70	1.31	1.68	0.18	0.95	1.66

Table 2

Average distances of the nasospinale-to-jugale midpoint from the infraorbital foramen according to the location of the midpoint relative to the foramen in fetal/infant, child, and adolescent populations.

Direction Relative to the IOF	6 months fetal age - <2 years		2 years - <12 years		12 years - 18 years	
	Mean (mm) *	±SD	Mean (mm) *	±SD	Mean (mm) *	±SD
Superior	–	–	0.17	0.70	–	–
Superolateral	0.72	1.67	0.12	0.48	–	–
Lateral	1.56	2.36	0.34	0.93	0.10	0.51
Inferolateral	–	–	0.46	1.37	0.35	1.34
Inferior	–	–	0.32	1.14	0.88	2.53
Inferomedial	–	–	–	–	0.45	1.54
Medial	–	–	0.11	0.48	0.28	1.17
Superomedial	–	–	–	–	–	–

* 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.