Research Article

Morphometric study of Infraorbital foramen in relation to inferior orbital margin in dry adult human skulls in North India

Fatima Begum[1*], Manik Sehgal[2], Rubinder Kaur[3]

[1]Department of Anatomy, Government Doon Medical College, Dehradun, Uttarakhand, India.
[2]Department of Orthopedic, Pt. Jawaharlal Nehru Government Medical College & Hospital, Chamba, Himachal Pradesh, India.
[3]Department of Anesthesia, Pt. Jawaharlal Nehru Government Medical College & Hospital, Chamba, Himachal Pradesh, India.

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Corresponding Author: ***Fatima Begum*** Email: ***fatima19june@gmail.com***

ABSTRACT

Background & Aim: Situated on the anterior maxilla, the infraorbital foramen (IOF) serves as the conduit for the infraorbital neurovascular pathway. Safe execution of regional maxillofacial blocks and invasive midface surgical approaches depends on accurate geographical anatomical data. This investigation sought to determine the dimensions of the IOF and quantify its vertical proximity to the inferior orbital margin (IOM) in adult dried human crania of North Indian origin.

Materials and Methods: In this cross-sectional anatomical study, 60 structurally sound, complete adult human skulls (comprising 120 bilateral sides) were aligned along the Frankfurt horizontal plane. The linear distance separating the upper border of the IOF from the lowest point of the orbit directly above, along with the transverse and vertical dimensions of the aperture, were quantified bilaterally with a divider compass and a 0.01-mm precision digital caliper. Data were subjected to descriptive summary and paired bilateral evaluation.

Results: The mean distance separating the IOF from the inferior orbital rim measured 6.79 ± 1.25 mm (range: 4.26–11.35 mm) on right sides and 7.11 ± 1.55 mm (range: 4.58–11.45 mm) on left sides. Vertical aperture diameters averaged 2.80 ± 0.55 mm (right) and 2.82 ± 0.45 mm (left), whereas horizontal aperture dimensions averaged 2.79 ± 0.72 mm (right) and 2.84 ± 0.71 mm (left). No significant bilateral asymmetry was detected across any parameters ($p > 0.05$).

Discussion & Conclusion: Morphometric baselines from this North Indian cohort align well with regional Indian data, yet diverge noticeably from Western and African craniometric cohorts.

Keywords: *Infraorbital foramen; Inferior orbital margin; Regional block; Maxillofacial surgery*

1. INTRODUCTION

Positioned on the anterolateral maxillary surface beneath the inferior orbital rim, the infraorbital foramen (IOF) marks a crucial surgical landmark. As the exterior terminal exit of the infraorbital canal, it transmits the infraorbital nerve-the major terminal extension of the maxillary nerve (V2) - accompanied by its companion vessels. Upon exiting the osseous canal, this nerve splits into superior labial, external nasal, and inferior palpebral branches to provide sensory reception to the upper lip, cheek, lateral nasal wall, and lower eyelid.

Comprehensive anatomical familiarity with the spatial localization of this aperture is indispensable across several medical domains:

- **Regional Anesthesia:** Blocking the infraorbital nerve provides targeted analgesia for cleft palate/lip repairs, midfacial dermatologic excisions, cosmetic rhinoplasty, and intractable trigeminal neuralgia. An inadvertent cranial trajectory during extraoral or intraoral approaches poses severe clinical risks, such as accidental orbital penetration, injury to the inferior oblique muscle, retrobulbar hematoma, or

vision impairment. Delineating the precise vertical separation between the IOF and the lower orbital boundary provides an essential safeguard against inadvertent intraorbital needle penetration.

- **Maxillofacial Reconstructive Surgery:** Operative interventions addressing Le Fort osteotomies, zygomaticomaxillary fractures, subciliary incisions, and Caldwell-Luc procedures require broad dissection across the anterior maxilla. Accurate knowledge of regional safe zones mitigates the risk of iatrogenic nerve laceration, permanent facial paresthesia, and extensive midface bleeding.

Extensive anthropometric reports reveal that the spatial arrangement and aperture size of the IOF vary considerably among distinct racial and geographic cohorts. Formulating regionally tailored baseline data remains essential for regional surgical practice. Consequently, this investigation quantifies the morphometry of the IOF and its proximity to the lower orbital margin in adult dry human crania from North India.

2. MATERIALS AND METHODS

Study Setting & Ethical Approval: This observational investigation was carried out in the Department of Anatomy at Muzaffarnagar Medical College, Uttar Pradesh, India. Ethical authorization was formally secured from the Institutional Ethics Committee (Ref. No. MMC/IEC/2025/324) prior to initiation.

Sample size: Calculated by Solvin's formula $n=N/ 1+Ne^2$

n= sample size

N= Total number of Population

e= Margin of error (10%)

$n= 10000/1+10000(10/10)^2 = 99$

according to formula sample size is 99 so here total 60 dry human skull included in study according to calculation 120 infraorbital foramina measured.

Sample Selection Criteria: The study analyzed 60 adult dry human crania devoid of documented sex records, yielding 120 bilateral sides (60 right, 60 left). Selection was based on dry crania within the departmental repository that satisfied strict morphological preservation standards. Skulls with intact facial skeletons, fully defined orbital rims, undamaged maxillae, and distinct foraminal apertures were selected. Specimens displaying developmental abnormalities, pathological bone erosion, midfacial fractures, or pediatric features were excluded.

Measurement Protocol: Crania were positioned in the standard Frankfurt horizontal plane. A single operator recorded all bilateral parameters using a sharp-pointed compass transferred directly onto an electronic digital Vernier caliper with 0.01 mm precision:

- **IOF to Inferior Orbital Margin (IOF–IOM):** The shortest vertical span between the uppermost margin of the IOF and the corresponding lowest border of the orbital rim immediately above **(Figure 1)**



Fig. 1 IOF- IOM

- **Vertical Aperture Height:** The maximal vertical distance spanning the superior and inferior boundaries of the foramen **(Figure 2).**



Fig. 2 Vertical Diameter

- **Horizontal Aperture Width:** The maximal transverse distance measured across the medial and lateral margins of the foramen **(Figure 3).**



Fig. 3 Horizontal Diameter

Statistical Analysis: Data were processed using SPSS software. Continuous variables are presented as mean ± standard deviation (SD), with corresponding minima and maxima. Bilateral differences (right vs. left) were evaluated via Student's paired t-test, with $p < 0.05$ considered statistically significant.

3. RESULTS

A total of 120 sides from 60 adult dry crania were evaluated.

Distance Between the Infraorbital Foramen and Inferior Orbital Margin (IOF–IOM)

The mean vertical distance spanning the upper margin of the IOF and the orbital rim was 6.79 ± 1.25 mm on the right side and 7.11 ± 1.55 mm on the left side.

Table 1: Vertical separation between the superior margin of the IOF and the inferior orbital margin.

Side	Mean (mm)	SD (±)	Minimum (mm)	Maximum (mm)
Right (n = 60)	6.79	1.25	4.26	11.35
Left (n = 60)	7.11	1.55	4.58	11.45

Measurements ranged between 4.26 mm and 11.35 mm on the right, and 4.58 mm to 11.45 mm on the left (Table 1). The observed bilateral difference was not statistically significant ($p = 0.21$).

Aperture Dimensions of the Infraorbital Foramen

The average vertical diameter was 2.80 ± 0.55 mm on the right (range: 1.52–3.73 mm) and 2.82 ± 0.45 mm on the left (range: 1.86–3.77 mm). The transverse diameter averaged 2.79 ± 0.72 mm on the right (range: 1.30–4.26 mm) and 2.84 ± 0.71 mm on the left (range: 1.32–4.09 mm). Neither dimension exhibited statistically significant bilateral variation ($p > 0.05$).

Table 2: Dimensions of the infraorbital foramen.

Parameter	Side	Mean (mm)	SD (±)	Min (mm)	Max (mm)
Vertical Diameter	Right	2.80	0.55	1.52	3.73
Vertical Diameter	Left	2.82	0.45	1.86	3.77
Horizontal Diameter	Right	2.79	0.72	1.30	4.26
Horizontal Diameter	Left	2.84	0.71	1.32	4.09

4. DISCUSSION

A comprehensive grasp of the structural dimensions of the IOF is essential for oral and maxillofacial surgeons, plastic surgeons, and anesthesiologists. The current data establish that in adult North Indian crania, the IOF is situated an average of 6.79 mm (right) and 7.11 mm (left) beneath the inferior orbital rim, displaying mean cross-sectional diameters close to 2.8 mm with marked symmetry between sides.

Contextual Analysis with National and Global Literature

The mean IOF-to-rim distances reported here correspond closely with earlier Indian craniometric series. Boopathi *et al.,* [15], documented comparable averages of 6.49 mm (right) and 6.65 mm (left) in South Indian specimens, while Tewari *et al.*, documented 7.09 mm and 6.95 mm. Varshney *et al.,* [17], documented slightly higher intervals of 7.65 mm and 7.11 mm, whereas Singh documented lower values of 6.12 mm and 6.19 mm.

In contrast, reports from outside India present marked morphometric variance. Cadaveric assessments in North American cohorts by Aziz *et al.,* [11], revealed considerably higher clearances (8.3 mm right, 8.1 mm left), whereas Macedo et al. observed 6.28 mm and 6.45 mm in

Brazilian crania. Such discrepancies emphasize the influence of ethnic and ancestral diversity on craniofacial dimensions.

Table 3: Comparison of mean IOF–IOM distances across documented series.

Study / Authors	Geographic Population / Sample	Right (mm)	Left (mm)
Present Study	North Indian (n = 60 crania)	6.79	7.11
Boopathi et al. [15]	South Indian (n = 80 crania)	6.49	6.65
Tewari et al. [16]	Indian (n = 50 crania)	7.09	6.95
Singh [13]	North/Central Indian (n = 50 crania)	6.12	6.19
Varshney et al. [17]	Indian (n = 150 crania)	7.65	7.11
Aziz et al. [11]	North American (n = 47 cadavers)	8.30	8.10
Macedo et al. [18]	Brazilian (n = 295 crania)	6.28	6.45

Aperture dimensions in our series averaged approximately 2.80 mm in vertical height and 2.81 mm in horizontal width. These values fall somewhat below those documented by Sharma et al. (3.94 mm and 3.31 mm) and Singh (3.39 mm and 3.19 mm), likely reflecting minor variations in landmark selection and natural regional polymorphism.

Surgical and Anesthetic Implications

The proximity of the IOF to the orbital margin holds direct clinical relevance. The lowest recorded clearance in this cohort was 4.26 mm. During extraoral infraorbital blocks, superior needle advancement beyond this threshold risks piercing the lower orbital margin, traversing the septum, damaging the inferior oblique muscle, or puncturing the globe. Clinicians should maintain a palpating finger along the lower orbital boundary during needle passage to act as a protective barrier.

Similarly, for maxillofacial surgeons operating via subciliary access or executing rigid fixation of orbitozygomatic fractures, recognizing this clearance zone prevents accidental neurovascular transection, decreasing post-surgical paresthesia over the midface.

Forensic and Anthropometric Value

Quantifying regional osteological dimensions is vital for anthropological classification, forensic midfacial reconstruction, and biomedical hardware manufacturing. Because skeletal indexes diverge across ancestral lineages, population-specific data aid forensic personnel in establishing biological profiles and assist biomedical engineers in designing anatomical plating systems tailored to the typical contours of the local population.

Study Limitations

A key constraint of this study is the absence of documented ante-mortem variables (such as explicit age, biological sex, and specific lineage) for the skeletal collection.

5. CONCLUSION

In adult dry skulls from North India, the upper border of the infraorbital foramen lies at a mean distance of 6.79 ± 1.25 mm on the right and 7.11 ± 1.55 mm on the left below the inferior orbital margin, demonstrating strong bilateral symmetry. The aperture displays an average diameter of approximately 2.8 mm. Because the distance to the orbital margin can be as short as 4.26 mm, these values provide safe operational boundaries for regional blocks and midface reconstructive procedures. Subsequent studies using high-resolution computed tomography (HRCT) in living clinical subjects will help further validate these osseous findings.

DECLARATIONS

Conflict of Interest: The authors state that they have no competing financial or personal interests.

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Ethical Approval: Authorized by the Institutional Ethics Committee, Muzaffarnagar Medical College (Ref. No. MMC/IEC/2025/324, dated 24/09/2025).

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REFERENCES

1. Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, *et al.*, editors. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th

ed. London: Churchill Livingstone; 2008. pp. 511-520.
2. Gardner E, Gray DJ, O'Rahilly R. Anatomy: A Regional Study of Human Structure. 4th ed. Philadelphia: Saunders; 1986.
3. Sinnatamby CS. Last's Anatomy: Regional and Applied. 12th ed. Edinburgh: Churchill Livingstone Elsevier; 2011. pp. 360-375.
4. Hwang K, Han JY, Battuvshin D, Kim DJ, Chung IH. Communication of infraorbital nerve and facial nerve: Anatomic and histologic study. *J Craniofac Surg.* 2004;15(1):88-91.
5. Berge JK, Bergman RA. Variations in size and symmetry of foramina of the human skull. *Clin Anat.* 2001;14(6):406-413.
6. Esper RS, Yara J, Yamamura Y, Cricenti SV. Relações anatômicas do ponto de acupuntura E-2 (Sibai) localizado no forame infra-orbital. *Rev Paul Acupunt.* 1998;4:19-21.
7. Du Toit DF, Nortjé C. The maxillae: Integrated and applied anatomy relevant to dentistry. *SADJ.* 2003;58(8):325-330.
8. Kazkayasi M, Ergin A, Ersoy M, Tekdemir I, Elhan A. Microscopic anatomy of the infraorbital canal, nerve and foramen. *Otolaryngol Head Neck Surg.* 2003;129(6):692-701.
9. Malamed SF. Handbook of Local Anesthesia. 6th ed. St. Louis: Mosby Elsevier; 2012. pp. 190-205.
10. **[10]** Cutright B, Quillopa N, Schubert W. An anthropometric analysis of the key foramina for maxillofacial surgery. *J Oral Maxillofac Surg.* 2003;61(3):354-357.
11. Aziz SR, Marchena JM, Puran A. Anatomic characteristics of the infraorbital foramen: A cadaver study. *J Oral Maxillofac Surg.* 2000;58(9):992-996.
12. Apinhasmit W, Chompoopong S, Methathrathip D, Sansuk R, Phetphunphiphat W. Supraorbital notch/foramen, infraorbital foramen and mental foramen in Thais: Anthropometric measurements and surgical relevance. *J Med Assoc Thai.* 2006;89(5):675-682.
13. Singh R. Morphometric analysis of infraorbital foramen in Indian dry skulls. *Anat Cell Biol.* 2011;44(1):79-83.
14. Gruber W. Ueber den infraorbitalcanal bei dem menschen und bei den säugethieren. Ar*ch Pathol Anat Physiol Klin Med.* 1878;72(4):494-496.
15. Boopathi S, Chakravarthy MS, Dhalapathy S, Anupa S. Anthropometric analysis of the infraorbital foramen in a South Indian population. *Singapore Med J.* 2010;51(9):730-735.
16. Sharma S, Sharma A, Thakur C, Modi BS. Anthropometric measurements of infraorbital foramen and its anatomic variations in dried human skulls. *Int J Anat Res.* 2015;3(4):1487-1490.
17. Varshney R, Sharma PK, Roy S. Morphometric study of infraorbital foramen in relation to surrounding anatomical landmarks in human dry skulls. *Int J Anat Res.* 2017;5(3.2):4257-4260.
18. Macedo VC, Cabrini RR, Faig-Leite H. Infraorbital foramen location in human dry skulls of Brazilians. *Int J Morphol.* 2009;27(1):35-38.
19. Shaik HS, Shepur MP, Desai SD, Thomas ST, Maavishettar GF, Haseena S. Morphometric analysis of infraorbital foramen position in South Indian skulls. *Indian J Innovations Dev.* 2012;1(5):342-345.