



## Morphological and Morphometric Study of Infraorbital Foramen in South Indian Population

Haobam Rajajee Singh, Suganthi Rabi

Department of Anatomy, Christian Medical College Vellore

### Abstract

**Background:** The knowledge about the infraorbital foramen (IOF) is important to avoid iatrogenic injury to the infraorbital nerve during maxillofacial surgeries. This study aims to observe the shape, position and size of IOF and to measure its distance from surgically important bony landmarks.

**Materials and Methods:** A total of 50 dry skulls were studied for the shape, position and size of the IOF. Its distance from infraorbital margin, lateral margin of the piriform aperture and alveolar border was measured.

**Results:** The IOF was oval in 76%, circular in 26%, triangular in 12% and D-shaped in 2% of the skulls studied. Accessory IOF were present in 10%. Bony projection close to the upper margin of the IOF was seen in 40%. IOF was seen in line with the 2<sup>nd</sup> premolar on the right side in 82% and in line with the 1<sup>st</sup> molar on the left side in 72%. The mean distance of the IOF from infraorbital margin was  $6.27 \pm 1.60$  mm on the right and  $5.96 \pm 1.60$  mm on the left; from the alveolar border  $25.23 \pm 3.78$  mm on the right and  $23.99 \pm 3.84$  mm on the left and from the lateral margin of piriform aperture was  $13.81 \pm 1.95$  mm on the right and  $11.55 \pm 1.61$  mm on the left side. The mean transverse diameter of the IOF on the right was  $2.76 \pm 0.9$  mm and  $3.03 \pm 0.65$  mm on the left and the vertical diameter was significantly higher on the right ( $3.09 \pm 0.61$  mm) when compared to the left ( $2.82 \pm 0.68$  mm).

**Conclusion:** The data provided in this study would help the anaesthetist to do successful regional nerve block during midfacial surgeries in South Indian population.

### Introduction

The infraorbital foramen (IOF) serves as an important landmark for surgical, local anaesthetic and various other invasive procedures for the oral and maxillofacial surgeries.<sup>1</sup> The IOF present in the maxilla transmits the infraorbital vessels and nerve. It lies about 1cm below the infraorbital margin.<sup>2</sup> The IOF is relatively larger than the supraorbital foramen and vary in shape and position.<sup>3</sup> The position of the IOF varies in different racial groups.<sup>4,5</sup> Its position in relation to the maxillary teeth is also varied among various population.<sup>6,7</sup> An adequate knowledge of the regional anatomy of IOF is necessary to avoid injury to the neurovascular structures passing through it.<sup>1</sup> The aim of this study was to document the shape and size of IOF and to investigate its relation to the surrounding surgically important landmarks like infraorbital margin, the lateral margin of the piriform aperture and alveolar border.

### Material and Methods

The study was done in a total of 50 dry skulls, available in our department. Skulls broken at the region of the piriform aperture, infraorbital margin and maxillary alveolar border were excluded from the study. Age and gender records were not available.

### Gross Anatomical Observations

The shape of the infraorbital foramen, presence of any bony projection and accessory infraorbital foramen were observed.

## Anatomical measurements

The measurements were taken with the help of a Vernier caliper.

1. The maximum transverse and vertical dimensions of the IOF were measured.
2. The distance of the IOF from the following landmarks were measured: (Figure 1)
  - Vertical distance from the upper margin of the IOF to the lower rim of the orbit
  - Vertical distance from the lower margin of IOF to the alveolar border
  - Transverse measurement from the medial margin of the IOF to the lateral margin of the piriform aperture



Figure 1. A - Vertical distance from the upper margin of the IOF to the lower rim of the orbit. IOF - infraorbital foramen; B - vertical distance from the lower margin of IOF to the alveolar border; C - transverse measurement from the medial margin of the IOF to the lateral margin of the piriform aperture

## Results

All the 50 skulls examined revealed the presence of infraorbital foramen bilaterally. The shape of the IOF was oval in 38 specimens (76%), triangular in 6 specimens (12%), circular in 13 specimens (26%) and D shaped in 1 specimen (2%)(Figure 2).

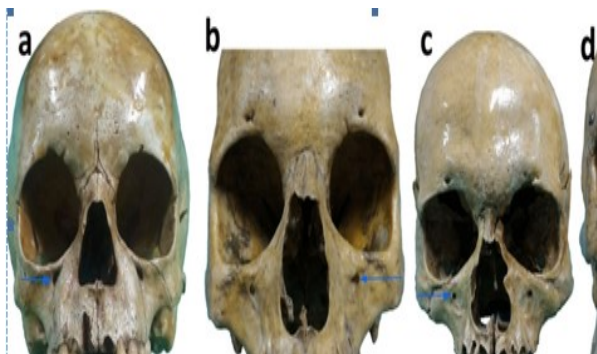


Figure 2. Showing the different shaped infraorbital foramen (IOF) A - oval shaped IOF; B - triangular shaped IOF; C - circular shaped IOF; D - D shaped IOF

Accessory IOF were seen in 5 specimens (10%), unilateral in 4 specimens (8%) and bilateral in 1 specimen (2%) (Figure 3).



Figure 3. Arrow indicates accessory IOF

Presence of bony projections close to the upper margin of the infraorbital foramen were seen in 20 specimens (40%), in 8 specimens (16%) it was unilateral and 12 specimens (24%) it was present bilaterally (Figure 4).



Figure 4. Arrow indicates bilateral presence of bony projections

The position of IOF in relation to the maxillary teeth is shown in Table 1. The IOF was seen between the 1<sup>st</sup> premolar and the 2<sup>nd</sup> molar. In most of the cases, IOF was seen in line with the 2<sup>nd</sup> premolar on the right side (82 %) and in line with the 1<sup>st</sup> molar on the left side (72 %). Such pattern of having IOF in line with 2<sup>nd</sup> premolar on the right and in line with 1<sup>st</sup> molar on left was observed in 30 specimens (60%).

**Table 1. Position of Infraorbital Foramen(IOF) (n=100 sides)**

Position of IOF	Right	Left
In line with 1st premolar	1	-
Between the 1st premolar and 2nd premolar	1	-
In line with 2nd premolar	41	10
Between 2nd premolar and 1st molar	1	3
In line with 1st molar	6	36
Between 1st and 2nd molar	-	1

The transverse diameter of the IOF on the right side ranged from 1.59 mm to 6.24 mm with the mean of  $2.76 \pm 0.9$  mm and that of the left side ranged from 1.68 mm to 4.59 mm with the mean of  $3.03 \pm 0.65$  mm. The vertical diameter on the right side was significantly higher on the right side than on the left side ( $p=0.03$ ) (Table 2).

The mean distance of the IOF from the lower margin of the orbit was  $6.27 \pm 1.60$  mm on the right side and  $5.96 \pm 1.60$  mm on the left side. The mean distance of the IOF from the alveolar border is  $25.23 \pm 3.78$  mm on the right side and  $23.99 \pm 3.84$  mm on the left side. The mean distance of the IOF from the lateral margin of piriform aperture was significantly higher on the right side ( $13.81 \pm 1.95$  mm) than the left ( $11.55 \pm 1.61$  mm) (Table 2).

**Table 2. Measurement of diameter of infraorbital foramen (IOF) and its distance from various reference points.**

	Right				Left		
	Min	Max	Mean	SD	Min	Max	Mean
Transverse diameter	1.59	6.24	2.76	0.9	1.68	4.59	3.03
Vertical diameter	1.97	5.11	3.09	0.61	1.55	4.4	2.82
Distance between IOF and IOM	2.72	10.76	6.27	1.60	3.11	10.40	5.96
Distance between IOF and AB	14.87	33.43	25.23	3.78	14.42	30.98	23.99

IOM -Infraorbital margin; AB - Alveolar border; PA - Piriform aperture

## Discussion:

It is important to identify the IOF accurately for both diagnostic and clinical procedures involving maxillofacial surgeries and pain management in cases of the maxillary nerve neuralgia. The infraorbital nerve which emerges out of this foramen could be damaged during surgical manoeuvres resulting in paresthesia or anaesthesia. With increasing popularity of the endoscopic procedure but with limited visibility, it is essential to know the anatomical position of the foramen and its possible variations.<sup>8,9</sup> The position of IOF varies in racial and gender groups.<sup>4,5</sup> In the present study the IOF was present bilaterally in all the 50 specimens examined and this is in accordance with the previous studies.<sup>1,10,11</sup> The shape and size of the IOF were also studied previously to explore its favourability for introduction of the needle.<sup>9</sup> According to Ilayperuma et al., 2010 IOF was of either oval, semilunar or round in shape.<sup>12</sup> Aggarwal et al. reported triangular and D-shaped IOFs in addition to the previously described oval, semilunar or round shape IOF.<sup>9</sup> In our study we observed oval, triangular, circular and D - shaped IOF and the most common was the oval shaped IOF seen in 76%. This is in accordance with Aggarwal et al. who reported oval shaped IOF in 81.95% in Indian population. Boopathi et al., who reported oval shaped IOF in 55% on the right side and 51.25% on the left side in South Indian population while Elsheikh et al. reported higher incidence of semilunar shaped IOF followed by round shaped IOF in Egyptian population.<sup>8,9,13</sup>

A wide variation in the occurrence of accessory IOF among different populations has been reported. The earliest account of the accessory IOF was given by Gruber in 1875 as reported by Leo et al.<sup>14</sup> According to Gruber the number of accessory IOF may vary from 1 to 5. The incidence of single or double accessory IOFs ranged from 2.2% to 18.2%.<sup>6,15,16</sup> Kadanoff et al., reported the incidence of double accessory IOF in 9 %, triple in 0.5% and more than 3 foramina in 0.3% of the 1400 skulls studied.<sup>17</sup> Accessory IOF was studied from 4 different geographical location by Berry and he reported the incidence to be 6.4% and 8.7% in Burmese males and females; 12.5% and 7.9% in North American males and females, 18.2% and 12.5% in Mexican males and females, 2.2% and 4.8% in English males and females.<sup>18</sup> Boopathi et al. reported higher incidence of accessory IOF in the Indian population (16.25%).<sup>13</sup> The occurrence of accessory IOF has been shown to vary on different sides of the cranium according to Tezer et al. 2011 and Bressan et al 2004.<sup>19,20</sup> Bressan et al. reported the occurrence of accessory IOF as 4.7% in Italian population and it was more common on the left side (2.16%) than on the right side (1.22%).<sup>20</sup> In the current study the presence of accessory foramen were observed in 10% of the skulls studied, of which only 2% showed bilateral presence of accessory foramen.

This is in contrast to Elsheikh et al. who reported bilateral presence of accessory foramen in most of the skulls studied except in one male skull which showed unilateral accessory IOF and in a female skull, bilateral IOF on one side and single on the other side. In previous studies, duplication of the infraorbital neurovasculature bundle have been reported and both the IOF and accessory IOF were observed to have their own neurovascular bundle.<sup>21,22</sup> The knowledge about the variable presence of an accessory foramen and thus an accessory branch of the nerve is important for the surgeon dissecting the midface region in order to avoid iatrogenic injury to the duplicated infraorbital nerve and also to gain sufficient local anaesthesia.<sup>21</sup>

In the current study, 20 skull (40%) showed a bony protuberance close to the upper margin of the infraorbital foramen. Such bony protuberance was noticed by Lee et al. (2006) in 31% and Aggarwal et al. in 22%.<sup>23,9</sup> Presence of such bony protuberance could hinder the needle insertion in the IOF.

Both the vertical and transverse diameter of IOF reported in this study is slightly smaller than that being reported in other population by Nanayakkara et al. in Sri Lankan population and Singh in North Indian population.<sup>24,25</sup> In the study done by Aziz et al. the average width of the infraorbital foramen was 4.5 mm in both sexes with a range of 1 to 7 mm  $\pm$  1.1mm.<sup>6</sup> In the present study, the vertical diameter was significantly higher on the right side than on the left side. But Elsheikh et al., reported significantly higher transverse diameter on the right side in females.

Variation in the position of the IOF is not an unusual pattern. Knowing the definitive location of the IOF is the certain way to reduce the chances of iatrogenic damage to the nerve during maxillofacial surgery or while trying to target a needle into this foramen for the nerve blockage. It is of great importance to establish a constant reference point for a successful percutaneous intervention. Various point of reference has been established in previous research for the needle insertion and most commonly the 2<sup>nd</sup> maxillary premolar tooth forms the basis for several infraorbital nerve block technique. While most of the studies showed the most common position was in line with 2<sup>nd</sup> premolar, the second most common position was either in line with 1<sup>st</sup> premolar<sup>6,8</sup> or in between 1<sup>st</sup> and 2<sup>nd</sup> molar.<sup>1,12</sup> In the present study, the IOF most commonly present in line with the 2<sup>nd</sup> premolar tooth on the right side but in line with upper 1<sup>st</sup> molar tooth on the right (58%) which is different from other reports.

The infraorbital margin (IOM) is also being used as the reference point of view. The mean distance between the IOM and the IOF being 6.27 mm  $\pm$  1.6 mm on the right side and 5.96 mm  $\pm$  1.60 on the left side, which is in accordance with previous studies.<sup>8,11</sup> Other studies have mentioned a larger distance between the infraorbital margin and IOF. Chung reported the average distance from the infraorbital margin to the center of the infraorbital foramen was 8.6 mm in Korean population and Rahana et al. reported a distance of 8 mm between infraorbital margin and IOF.<sup>11,15,26</sup>

Another reference point which has been described in the literature is the distance between the IOF and the lateral margin of the piriform aperture. The average distance reported in the previous studies ranged from 14 to 17 mm.<sup>7,15,27</sup> In the present study the mean distance was 13.81 mm  $\pm$  1.95 mm on the right side and 11.55 mm  $\pm$  1.61 mm on the left side which is slightly lower than the previously reported one. However the limitation of this landmark is that it can neither be seen nor can't be palpated in living individuals so it would be of limited help.

The infraorbital nerve is also being approached from the oral cavity so keeping this in mind the distance between the IOF and the alveolar border was measured. We observed that in our study the mean distance was 25.23 mm  $\pm$  3.78 mm and the mean distance was 23.99 mm  $\pm$  3.84 on the left side and it was lower than the one reported by Kaskayasi (3.39 cm).<sup>16</sup>

The limitation of the study is since the gender and age record of the skulls used in the study is not available, their influence on the morphometry could not be assessed.

## Conclusion

In conclusion, the results of the study confirms the racial differences in the shape and position of IOF. The knowledge of the distances from the surgically encountered anatomical landmarks would probably benefit the surgeons and anesthetist during facial surgeries related to the infraorbital nerve in South Indian population.

## Reference:

1. 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. Chotmaihet Thangphaet* **89**, 675–82 (2006).
2. Susan Stranding. *Gray's Anatomy*. 40th ed. London, UK: Elsevier; 2008.
3. Berge, J. K. & Bergman, R. A. Variations in size and in symmetry of foramina of the human skull. *Clin. Anat. N. Y. N* **14**, 406–13 (2001).
4. Cutright, B., Quillopa, N. & Schubert, W. An anthropometric analysis of the key foramina for maxillofacial surgery. *J. Oral Maxillofac. Surg.* **61**, 354–57 (2003).
5. Ongeti, K., Hassanali, J., Ogeng'O, J. & Saidi, H. Biometric features of facial foramina in adult Kenyan skulls. *Eur J Anat* **12**, 85–95 (2008).
6. Aziz, S. R., Marchena, J. M. & Puran, A. Anatomic characteristics of the infraorbital foramen: a cadaver study. *J. Oral Maxillofac. Surg.* **58**, 992–96 (2000).

7. Kazkayasi, M., Ergin, A., Ersoy, M., Tekdemir, I. & Elhan, A. Microscopic anatomy of the infraorbital canal, nerve, and foramen. *Otolaryngol.-Head Neck Surg. Off. J. Am. Acad. Otolaryngol.-Head Neck Surg.* **129**, 692–97 (2003).
8. Elsheikh, E., Nasir, W. F. & Ibrahim, A. A. S. Anatomical Variations of Infraorbital Foramen in Dry Human Adult Egyptian Skulls, Anthropometric Measurements and Surgical Relevance. *An International Journal* **5**, 125–29 (2013).
9. Aggarwal, A. *et al.* Anatomical study of the infraorbital foramen: A basis for successful infraorbital nerve block. *Clin. Anat. N. Y. N* **28**, 753–60 (2015).
10. K, O., J, H., J, O. & H, S. Biometric features of facial foramina in adult Kenyan skulls. *Eur. J. Anat.* **12**, 89–95 (2018).
11. Chung, M. S., Kim, H. J., Kang, H. S. & Chung, I. H. Locational relationship of the supraorbital notch or foramen and infraorbital and mental foramina in Koreans. *Acta Anat. (Basel)* **154**, 162–66 (1995).
12. Ilayperuma, I., Nanayakkara, G. & Palahepitiya, N. Morphometric Analysis of the Infraorbital Foramen in Adult Sri Lankan Skulls. *Int. J. Morphol.* **28**, 777–82 (2010).
13. Boopathi, S., Chakravarthy Marx, S., Dhalapathy, S. L. & Anupa, S. Anthropometric analysis of the infraorbital foramen in a South Indian population. *Singapore Med. J.* **51**, 730–35 (2010).
14. Leo, J. T., Cassell, M. D. & Bergman, R. A. Variation in human infraorbital nerve, canal and foramen. *Ann. Anat. Anat. Anz. Off. Organ Anat. Ges.* **177**, 93–95 (1995).
15. Hindy, A. M. & Abdel-Raouf, F. A study of infraorbital foramen, canal and nerve in adult Egyptians. *Egypt. Dent. J.* **39**, 573–80 (1993).
16. Kazkayasi, M. *et al.* Certain anatomical relations and the precise morphometry of the infraorbital foramen--canal and groove: an anatomical and cephalometric study. *The Laryngoscope* **111**, 609–14 (2001).
17. Kadanoff, D., Mutanoff, S. . & Jordanov, J. Über die "Hauptöffnungen resp. incisurae des Gesichtssch " adels. *Morphologisches Jahrbuch* **115**, 405–07 (1970).
18. Berry, A. C. Factors affecting the incidence of non-metrical skeletal variants. *J. Anat.* **120**, 519–35 (1975).
19. Tezer, M., Ozturk, A., Akgul, M., Gayretli, O. & Kale, A. Anatomic and morphometric features of the accessory infraorbital foramen. *J. Morphol.Sci* **28**, 95–97 (2011).
20. Bressan, C. *et al.* Descriptive and topographic anatomy of the accessory infraorbital foramen. Clinical implications in maxillary surgery. *Minerva Stomatol.* **53**, 495–05 (2004).
21. Bahrami, A., Saman, M. & Ducic, Y. Duplicate Infraorbital Nerve - An Uncommon Anatomical Variation. *JSM Oro Facial Surg* **1**, 1001 (2016).
22. Tubbs, R. S., Loukas, M., May, W. R. & Cohen-Gadol, A. A. A variation of the infraorbital nerve: its potential clinical consequence especially in the treatment of trigeminal neuralgia: case report. *Neurosurgery* **67**, onsE315; discussion onsE315 (2010).
23. Lee, U.-Y., Nam, S.-H., Han, S.-H., Choi, K.-N. & Kim, T.-J. Morphological characteristics of the infraorbital foramen and infraorbital canal using three-dimensional models. *Surg. Radiol. Anat. SRA* **28**, 115–20 (2006).
24. Nanayakkara, D., Peiris, R., Mannapperuma, N. & Vadysinghe, A. Morphometric Analysis of the Infraorbital Foramen: The Clinical Relevance. *Anatomy Research International* (2016).
25. Singh, R. Morphometric analysis of infraorbital foramen in Indian dry skulls. *Anat. Cell Biol.* **44**, 79–83 (2011).
26. Rahman, M., Richter, E. O., Osawa, S. & Rhoton, A. L. Anatomic study of the infraorbital foramen for radiofrequency neurotomy of the infraorbital nerve. *Neurosurgery* **64**, 423-27; discussion 427-28 (2009).
27. Macedo, V., Cabrini, R. & Faig - Leite, H. Infraorbital formamen location in dry human skulls. *Braz.J.Morphol.Sci* **26**, 35–38 (2009).