International Journal of Anatomy and Research,
Int J Anat Res 2016, Vol 4(4):2992-3000. ISSN 2321-4287
DOI: http://dx.doi.org/10.16965/ijar.2016.391

Original Research Article

MORPHOMETRIC ANALYSIS OF INFRAORBITAL FORAMEN AND INCIDENCE OF ACCESSORY FORAMEN AND ITS CLINICAL IMPLICATIONS IN DRY ADULT HUMAN SKULL

M. Veeramuthu *[1], Ravi varman [2], Shalini [3], Manoranjitham [4].

*[1] Tutor, Department of Anatomy, Dhanalakshmi Srinivasan Medical College & Hospital, Tamil Nadu, India.

[2] Athiparasakthi Melmaruvathur Dental College, Tamil Nadu, India.

[3] Assistant Professor, Department of Anatomy, Dhanalakshmi Srinivasan Medical College & Hospital, Tamil Nadu, India.

[4] Professor, Department of Anatomy, Dhanalakshmi Srinivasan Medical College & Hospital, Tamil Nadu, India.

ABSTRACT

Background: Effective pain control in dentistry may be achieved by local anaesthetic techniques; so thorough knowledge of the possible anatomical and morphometric variations of the infra orbital foramen and accessory foramen is important for safe and successful regional anesthesia and for avoiding nerve injuries during surgery.

Materials and Methods: The study was conducted in 105 adult dry skulls. The distance from infraorbital foramen to infra orbital margin, lateral margin of the pyriform aperture, anterior nasal spine, zygomatic maxillary suture, supra orbital foramen/ notch, and the maxillary tooth were measured. Measurements were done bilaterally by using digital Vernier calliper. The size, shape, direction of the Infra Orbital Foramen (IOF) on both sides & the prevalence of accessory IOF were observed and analysed in the skulls. Observations thus made were compiled and tabulated followed by comparison using appropriate statistical tests.

Results: Mean distance of infraorbital foramen from infraorbital margin was 7.0± 1.64 mm, the mean distance between the infraorbital foramen and the piriform aperture was 17.5 ±2.84mm. Mean distance of infra orbital foramen from Anterior Nasal Spine and Zygomatic maxillary suture was 33.07± 3.43mm and 16.48± 2.80 mm respectively. Mean distance from supraorbital foramen/notch was 42.32 ± 2.51mm. The most common occurrence was semilunar shape (37%) followed by oval shape (29%),round shape (22%)and slit shape(12%).The mean vertical diameter of infra orbital foramen was 3.78 ± 1.03mm and transverse diameter was 3.87±1.52mm.The most common position of infra orbital foramen on right side was in line of long axis in between 1st and 2nd upper premolar(26%) and on left side at 2nd upper premolar (32%).The prevalence of accessory infraorbital foramen was 24.28%, while bilateral occurrence was only 9.5% and 14.76 % it was unilateral.

Conclusion: The findings of the present study can be helpful for clinicians when utilizing the infraorbital nerve block for various procedures in localizing the infraorbital foramen.

KEY WORDS: Infra orbital foramen, (IOF) Accessory Infra orbital foramen, Infra orbital Nerve block.

Address for Correspondence: Mr. M. Veeramuthu, Dhanalakshmi Srinivasan Medical College & Hospital, Siruvachur, Perambalur– 621 113, Tamil Nadu, India. **E-Mail:** veera3071985@gmail.com.

Access this Article online

Quick Response code

DOI: 10.16965/ijar.2016.391

Web site: International Journal of Anatomy and Research
ISSN 2321-4287
www.ijmhr.org/ijar.htm

Received: 29 Aug 2016
Peer Review: 31 Aug 2016
Revised: None

Accepted: 29 Sep 2016
Published (O): 31 Oct 2016
Published (P): 31 Oct 2016

INTRODUCTION

Infra orbital foramen (IOF), which transmits the infra orbital vessels and nerve lies about 1cm below the infra orbital margin [1]. It is present on the anterior surface of the maxilla, its location is essential in various clinical and surgical procedures such as maxillofacial surgeries, infra orbital nerve block etc. Infra orbital nerve block is used to anesthetize the lower eyelid, upper teeth and related gingivae, upper lip and lateral nose. Infra orbital nerve continues inferiorly over the anterior wall of the maxilla and appears on the face through the IOF, where it produces the palpebral, nasal and labial branches to supply the skin of the lower eyelid, conjunctiva, the lateral surface of the external nose and the upper lip, including the skin, mucous membrane and gum [2-4].Several authors have conducted studies on the morphometric assessment of the IOF [5-13].In these studies there are wide variation in the prevalence of accessory infra orbital foramens [5, 13-15].

The position of the infraorbital foramen helps to locate the infraorbital plexus region which we believe is a risk zone during plastic surgery [16]. Location of this foramen is also helpful to decrease risk during orbital surgery [17]. The aim of this study was to find out the incidence of variations in location, shape, dimensions and distance of the infraorbital foramen from various bony landmarks on both sides of the same skull and the incidence of accessory foramen. The findings of this study was also compared with the findings of other authors. This study, based on palpable points, can be used even in the case of oedema in the infraorbital area.

MATERIALS AND METHODS

One hundred and five dry adult human skulls of unknown age and sex were selected from the Departments of Anatomy and Forensic Medicine, and from the students of Dhanalakshmi Srinivasan Medical College and Hospital Perambalur, Tamilnadu. This study was approved by the Institutional Research and Ethics Committee (Human study) of Dhanalakshmi Srinivasan Medical College and Hospital, Perambalur, Tamilnadu .(IRCHS,No.DSMCH/IRCHS/042, date 25th July 2016). A criteria of exclusion was adopted in any skulls that showed signs of damage to orbital margin, as well as skulls where the IOF was found to be damaged unilaterally or bilaterally. In all the samples the presence of a complete maxillary bone was taken to be mandatory. Total sides studied were 210. The following measurements were made after aligning the skull in Frankfurt horizontal plane, by using digital Vernier calliper with least count of 0.01mm, rulers, double tipped compass and tape by direct vision method to evaluate the location of IOF on both sides of all skulls, the measurements were taken by two different persons and observations were recorded in the data collection form.

The following parameters were observed

1. Distance from the centre of IOF to Infraorbital margin along sagittal plane. (Figure-1 & Table-1)

2. Distance from the centre of IOF to Pyriform aperture (PA) along transverse plane. (Fig-1 & Table-1)

3. Position of IOF in relation to zygomatico maxillary suture along with horizontal plane. (Fig-1 & Table-1)

4. Distance from centre of IOF to anterior nasal spine. (Fig-1 & Table-1)

5. Size of infraorbital foramen (IOF).Vertical diameters (VD) and transverse diameters (TD) of IOF. (Fig-1&Table-1)

6. Shape of IOF (round, oval, semilunar and slit like). (Fig-2 & Table-2), direction of the foramen (infero medial, vertical, medial). (Fig-3 & Tab-3)

7 Position of IOF in relation to supraorbital foramen / notch (medial, lateral or central).

8. Position of IOF in relation to upper maxillary tooth.

9. Incidence of Accessory infra orbital foramen (one, two or multiple) on both sides noticed. (Fig-4 & Table-5)

The collected data was statically analysed with SPSS version 16.0 software. Observations thus made were compiled and tabulated. All the readings were expressed in mean and standard deviation in mm and were compared between right and left sides of skulls using Paired t' test.

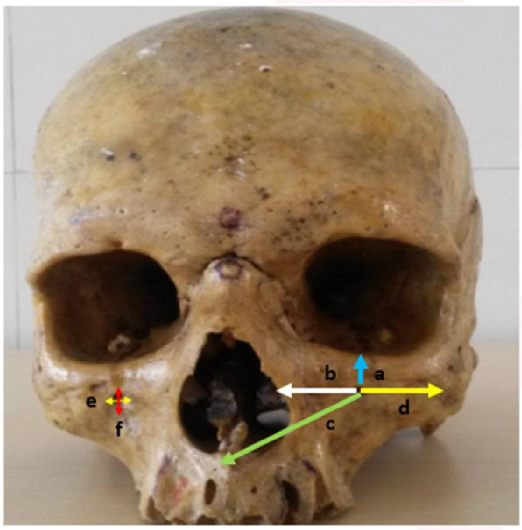
RESULTS

Table 1: Descriptive of the bilateral measurements of the infraorbital foramen.

Parameters	Right side			Left side			Combined		
	Mean in mm±SD	Min (mm)	Max (mm)	Mean in mm±SD	Min (mm)	Max (mm)	Mean in mm±SD	Min (mm)	Max (mm
IOF-IOR	7.22±1.64	5	13	6.78±1.64	4	11	7±1.64	5	12
IOF-PA	17.8±2.94	13	23	17.2±2.75	11	23	17.5±2.84	12	23
IOF-ZMS	15.16±2.67	10	21	17.8±2.94	13	23	16.48±2.80	11	22
IOF-ANS	32.62±3.49	26	40	33.52±3.37	27	38	33.07±3.43	26	39
IOF-SOF	41.74±2.39	36	53	42.9±2.64	37	53	42.32±2.51	36	55
VD	3.88±1.17	2	8	3.68±0.89	2	6	3.78±1.03	2	7
TD	3.82±1.58	2	10	3.92±1.46	2	10	3.87±1.52	2	10

IOF-Infraorbital foramen, IOR-Infraorbital rim, PA-Piriform aperture, ZMS-Zygomatico maxillary Suture, ANS- Anterior nasal spine, SOF- Supraorbital foramen / notch, VD- Vertical diameters, TD- Transverse diameters.

Fig. 1: Frontal view human skull showing the various morphometric measurements taken.



a : the measurement of the distance between the centre of the infraorbital foramen (IOF) and the infraorbital rim (IOR); b: the measurement of the distance between the centre of the infraorbital foramen (IOF) and the pyriform aperture(PA); c: the measurement of the distance between the centre of the infraorbital foramen (IOF) and the anterior nasal spine (ANS); d: the measurement of the distance between the centre of the infraorbital foramen (IOF) and the zygomatico maxillary suture; e: the measurement of the transverse distance between the medial and lateral margins of the IOF; f: the measurement of the vertical distance between the superior and inferior margins of the IOF.

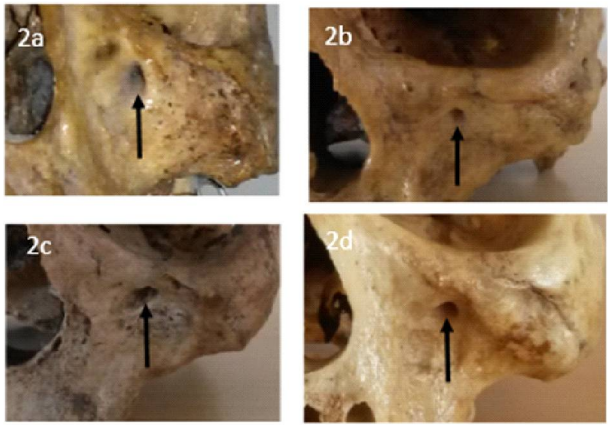
The infraorbital foramen (IOF) was present in all skulls and all the foramens were analysed.

Location and size of infraorbital foramen: The mean distance of the infraorbital foramen from the infraorbital rim, pyriform aperture, zygomatic maxillary suture, anterior nasal spine and supraorbital notch/ foramen on the right and left sides is tabulated in table 1. The mean vertical and transverse diameters on both sides is also tabulated in Table 1.

Table 2: Shape of the infra orbital foramen.

Shape	Right side		Left side		combined	
	No	%	No	%	No	%
Round	30	28	17	16	23	22
Oval	36	34	25	24	30	29
Slit like	6	6	19	18	13	12
semilunar	33	32	44	42	39	37
Total	105	100	105	100	105	100

Fig. 2: Photographs (frontal view) of dry adult human skulls of unknown age show (2a) a oval shaped IOF (arrow); (2b) a semilunar-shaped IOF (arrow); (2c) an slitlike-shaped IOF (arrow); and (2d) a round-shaped IOF (arrow).



Shape of the infraorbital foramen: Oval shaped infraorbital foramen was commonly observed on the right side 34% and semilunar shaped infraorbital foramen was commonly

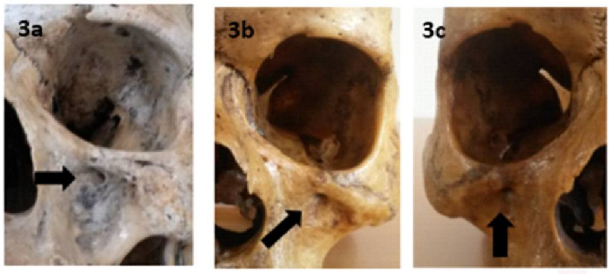
observed on the left side 42% (Table-2&Fig-2). In 37 % of the specimens semilunar shape was observed bilaterally. There was statistically significant difference in all the shapes of infraorbital foramen observed on the right and left sides- $p < 0.05$

Direction of IOF & position of IOF with the SOF: The IOF was most commonly directed in the inferomedial direction on both sides. The relative position of the infraorbital foramen in relation to the supraorbital foramen was evaluated (Table-3&Figure-3). The most common position for the infraorbital foramen was lateral to the supraorbital foramen in 58% of the specimens on the right side and 72% of the specimens on the left side (Table 3). There was no statistically significant difference in the direction of IOF and position of IOF in relation to SOF on the right and left sides- $p>0.05$.

Table 3: Direction of IOF & position of IOF with the SOF.

Direction	Right side		Left side		IOF Relation to SOF	Right side		Left side	
	No	%	No	%		No	%	No	%
Medial	11	10.4	17	16.19	Medial	13	12.1	13	12
Infero medial	69	65.71	71	67.71	Centre	31	30	17	16
vertical	25	23.8	17	16.19	Lateral	61	58	75	72
Total	105	100	105	100	Total	105	100	105	100

Fig. 3: Photographs (frontal view) of the dry adult human skulls of unknown age show (a) a medially directed (arrow); (b) a inferomedially directed (arrow); and (c) an vertically directed (arrow) intraorbital foramen.



Frequency of location of infraorbital foramen in relation to the upper teeth: The IOF was most frequently located between the first and the second upper premolars (26%) on the right side and at 2nd premolar on left side (32%). Followed by the next frequency occurrence was on right side at 2nd premolar (22%) and on left side between 1st and 2nd premolar (26%.) (Table 4). There was no statistically significant difference in the position of IOF on the right and left sides –P>0.05.

Table 4: Frequency of location of infraorbital foramen in relation to the upper teeth.

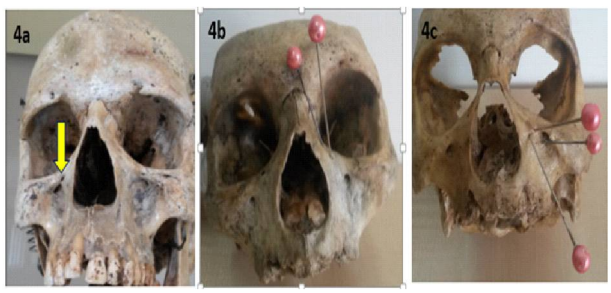
Location of IOF	Rt %	Lt %
At canine	6	6
B/W Canine & 1st Premolar	8	8
At 1st premolar	10	14
B/W 1st & 2nd premolar	26	26
At 2nd premolar	22	32
B/W 2nd premolar & 1st Molar	14	12
At 1st Molar	12	2
B/W 1st & 2nd Molar	2	_

Accessory infraorbital foramen: Out of 105 skulls, in 51 skulls accessory foramen was present. One accessory foramen was present in skulls unilaterally on right side in 10 (9.5%)skulls and on left side in 12(11.4%) skulls, occurrence on bilaterally was 6 (5.71%) skulls. Two accessory foramen was present unilaterally on right side in 4 (3.80%) and on left side in 2 (1.90%)skulls ,occurrence on bilaterally was 4 (3.80%) skulls.Three accessory foramen was present unilaterally on right side in 2 (1.90%) skulls and on left side in 1 (0.95%)skull , and there was no bilateral occurrence. (Table-5 & Fig-4)

Table 5: Accessory infraorbital foramen.

Side of skull	Frequency of accessory infraorbital foramen in 105 crania		
Number	1	2	3
Right side (Unilateral)	10	4	2
percentage	9.5	3.8	1.9
Left side (Unilateral)	12	2	1
percentage	11.4	1.9	0.95
Bilateral	6	4	
percentage	5.71	3.8	–

Fig.4: Photographs (frontal view) of dry adult human skulls of unknown age show the 4a:one accessory foramen in the arrow;4b:two accessory foramens; 4c; three accessory foramens.



Presence of Supraorbital foramen: In supra orbital margin at the junction of medial 1/3rd and lateral 2/3rd Supra-orbital notch/foramen is present. Supraorbital nerve and vessels pass through the foramen. Swimmers wearing goggles have also seen to have symptom of headache and neuralgia which is often more in persons having supraorbital notch rather than foramen because the nerve is more exposed in supraorbital foramen [18]. The supraorbital foramen was observed in 27 specimens on the right side and 25 specimens on the left side in our study. The supraorbital nerve is clinically important as it causes neuralgia especially, 'swimmers neuralgia'.

DISCUSSION

Infraorbital foramen is located near important anatomical structures like orbit, nose and oral cavity. The location of the infraorbital foramen assumes great importance because an infraorbital nerve block is essential during surgical procedures around the orbit, nose and buccal regions. The most common position of infraorbital foramen is in line of long axis of the second upper premolar. According to Hindy et al [19] 50% of infraorbital foramen was opposite the 2nd maxillary premolar. Varshney et al [20] has reported 64% of infraorbital foramen was opposite the 2nd maxillary premolar. In Tilak Raj et al [21] study, the location of IOF was found in line of second premolar in 81.4% of skulls which was higher than what mentioned by Hindy [19] and Varshney [20]. In our study the IOF was most frequently located between the 1st and the 2nd upper premolars (26%) on the right side and at the level of 2nd premolar on left side (32%).(Table 4).

The distances between the infraorbital foramen and the midpoint of the infraorbital margin vary from 4 to 12 mm in several studies [13, 14, 19] but the same distance ranged from 2 to 11.5 mm in Rajani Singh study.[22] In our study the distance ranged from 5-12 mm.The range of these distances was wider on lower side among Indians which is an alert to surgeons treating Indians anywhere in the world.

The mean distance between the infraorbital foramen and the infraorbital margin was 7.0 mm in current study which was very close to that of Boopathi S who has reported the distance between infraorbital foramen and the infraorbital margin to be 6.57 mm.[28]

Table 6: Comparison of mean distance from infra orbital rim (IOR) between present study and the previous studies.

Study	No.of skulls	Mean IOR on right side (Mean in mm ± SD)	Mean IOR On left t side (Mean in mm ± SD)
Aziz et al. 2000 [13]	47	8.3±1.9	8.1±1.9
Elias et al. 2004 [24]	210	6.71± 1.7	6.83± 1.83
Agthong et al. 2005 [23]	110	7.8±0.2	8.0±0.2
Macedo et al. 2009 [25]	295	6.28±1.79	6.45±1.76
Lopes et al. 2009 [26]	99	6.57 ±1.70	6.76± 1.64
Boopathi et al. 2010 [28]	80	6.49±1.26	6.65±1.30
Gour et al. 2010 [27]	100	6.52±1.79	6.42±1.70
Singh S, 2011 [29]	55	6.12±1.79	6.19±1.81
Lokanayaki, 2013 [30]	100	6.12±1.43	6.53±1.53
Present study	105	7.22±1.64	6.78±1.64

On comparison of mean distance from IOF to IOR between the present and previous studies it was observed that the mean distance was higher than all the other studies, but coincides with Agthong et al [23] and Azis et al [13] studies on the right side. But on the left side our study was coincides with others and lower than the Agthong et al [23], Azis et al [13] studies. The data listed in the table.6 are done in different regions and populations, like Brazil, India, Thailand, Egypt and different ethnic groups in New York. The studies done on Thai skulls [25] and different ethnic groups in New York [13] shows higher value than rest of the others. Our value is comparable with all the studies done in the region of Brazil and India.

Table 7: Comparison of distance between (b/w) IOF and Piriform aperture with other studies.

Study	Distance b/w IOF to PA (mean±SD in mm)	
	Right	Left
Hindy 1993 [19] (30 skull and 15 cadavers	14.7 ± 2.7	14.7 ± 2.7
Singh 2011 [29] (55 skull)	15.31	15.8
Bharti 2013 [32] (100 skull)	16.01	16.01
Tilak Raj 2014 [21] (70 skulls)	15.79±1.76	16.14±1.72
Ukoha ukoha ukoha2014 [33] (130 skulls)	19.36±3.54	18.27±2.94

A major factor that inhibits dentists from using the infraorbital nerve block is the fear of injury to the patient's eye. [31] Thus, knowledge of the distance between the IOF and IOR may be useful in identifying the location of the danger zone during dissection of the fracture of the anterior maxillary wall or infraorbital wall, as well as during other surgical procedures.

The present work revealed that the mean distance of infraorbital foramen from the piriform aperture was 17.5mm. Table 7 compares the results with those of other authors. This was higher than the result obtained from measuring the same parameter by Hindy[19] ,Singh [29] ,Bharti [32],Tilak raj [21] and lower than the result of Ukoha ukoha ukoha 2014 [33]. Such differences could be attributed to racial differences and ethnicity.

The present study reported the distance of infraorbital foramen in relation to anterior nasal spine (ANS) to be 33.07 mm.This result was lower than those obtained by Lopes et al [26] and Agthong et al.[23]and higher than the Ukoha ukoha ukoha 2014 [33]. It goes to say that data from one population cannot be transposed to another population, because they are population-specific.

The mean distance of infraorbital foramen in relation to zygomatic maxillary suture in the present study was 15.16 mm on right side and 17.8 mm on left side.This result was higher than the Tilak raj et al [21](Right side 14.71,Left side 14.83),Priya roy et al[34] (Right side 12.4 ,Left side 12.0), Cutright observed that IOF was 3mm medial to the Zygomatico maxillary suture[35], Apinhasmit stated 2.15 mm medial to Zygomatico maxillary suture suture[36]. Blanton and Jeske et al found the IOF 5mm below Zygomatico maxillary suture suture[37]. Sivavadivel swaminathan et al observed 2.8mm from Zygomatico Maxillary suture[38]studies .In present study ,the distance between SOF –IOF was right side 41.74±2.39 mm and left side 42.9±2.64 mm. This is higher than the study of Priya roy et al (Right side 36.1±14.3 mm , Left side 37.6±13.3 mm)[34] Studies.

Table 8: Comparison of vertical and transverse diameter of IOF found in this study from finding of different studies.

Studies	Vertical diameter(mm)		Horizontal diameter(mm)	
	Right	Left	Right	Left
Singh 2011[29] (n=55)	3.75	3.39	3.52	3.19
Bharti 2013 [32] (n=100)	3.23±0.98	3.25±1.03	3±0.76	3.28±0.99
Tilak raj 2014 [21] (n=70)	2.93±0.78	3.08±0.85	3.05±0.79	3.27±0.85
Rajani singh 2011 [22] (n=55)	3.39±0.96	3.75±1.07	3.19±1.18	3.52±1.35
Boopathi et al 2010 [28] (n=80)	2.79 ± 0.79	2.85 ± 0.80	2.73 ± 0.73	3.00 ± 0.81
Present study 2016 (n=105)	3.88±1.17	3.68±0.89	3.82±1.58	3.92±1.46

In present study the mean and standard deviation of vertical diameter(mm) on right side was 3.88±1.17 and on left side was 3.68±0.89 and Horizontal diameter(mm) on right side 3.82±1.58,left side 3.92±1.46.The study of vertical measurement was coincides with the study of Singh[29], Bharti[32], Rajani Singh[22] and higher than the Tilak raj[21],Boopathi et al[28] and the study of horizontal measurement coincides with the Singh [29],Bharti[32], Tilak raj[21] ,Rajani singh[22] and the right side higher than the Boopathi et al [28] studies.(Table 8)

Most common shape of infraorbital foramen mentioned in the literatures is oval type. Oliveira et al [39] in 2012 and Hindy [19]1993 (65%) and Tilak raj[21]2014 (71.4%) found that infraorbital foramen was predominantly of oval shape in the skulls on both sides, followed by round shape. In present study semilunar shape was observed to be most common type the percentage was 37%.

Most of the IOF were directed downwards and medially as revealed by Elias[24] and Apihasmit[36].IOF in 13.78% of skulls was directed medially and vertically downwards in 6.12% skulls . IOF found by K K Gaur [27] directed downwards medially in 66.6%, downwards vertically in 24.2%, downwards anteriorly in 1.2%, medially in 8%..Boopathi et al, identified medially directed IOF in 5% of the skulls [28]. In the present study IOF mostly directed infero medially on right side 65.71%, left side side 67.71 %. The infraorbital nerve and its vessels run along the direction of the IOF while passing the needle to block the nerve, the groove may play an important role in succeeding the anaesthesia. The standard Anatomy texts describe the location of supraorbital and infraorbital foramina on the same sagittal plane

(Williams et al[3]; Sinnatamby[40], 1999). Such diversity in the location of infraorbital foramen may be attributed to race, age dentition and dietary factors (Chung et al[11]; Cutright et al[35]; Ongeti et al [41]. According to the results of Ilayperuma et al [42] majority of infraorbital foramina (68.52%) were located lateral to the supraorbital foramen and only 24.07% of the study subjects displayed both foramina in the same sagittal plane. In our study the majority of IOF was located lateral to the supra orbital foramen (SOF) it was on right side 58% and on left side 72%.

Berry et al [15] reported the frequency of accessory infraorbital foramen as 4.7% in Egyptians, 6.4% in Nigerian, 6.4% in Modern Palestinian, 6.7% in Indians (Punjabi), 6% in North Americans and7.5% in Burmese. Aziz et al [13] and Hindy et al [19] reported frequency of accessory infraorbital foramen to be 10% in adult Egyptians while Elias et al [24] reported frequency of accessory infraorbital foramen to be 14% in adult Brazilian population. Apinhasmit et al [36] observed frequency of accessory infraorbital foramen to be 3.6% in Thai adult population. Alok Kumar Singh et al [43] observed over all prevalence of accessory infraorbital foramen is 7.81%, while bilateral prevalence of accessory infraorbital foramen is only 1.56 %, however unilaterally accessory infraorbital foramen is present in 6.25% (2.34 % on right side and 3.9 % on left side).In the present study the incidence of over all accessory infraorbital foramens was 24.28% of skull , it was bilaterally present in 14.76% skulls and unilaterally present in 14.76% skulls.

The importance of the incidence and lateralization of the Infra orbital foramen is also evident in facial surgical procedures. The recognition of the presence of double or triple foramens is essential when the appropriate amount of anesthesia is applied, or it can be inadequate. The study of the Infra orbital foramen is also basic to prevent the potential risk for iatrogenic injury during facial surgeries due to the presence of additional branches of the infra orbital nerve.

CONCLUSION

The knowledge of the distances from surgically encountered anatomical landmarks in the present study may assist surgeons to localize the important maxillofacial openings, avoid injury to the neurovascular bundles and facilitate surgical, local anaesthetic and other invasive procedures. The data are of direct relevance to clinical practice and teaching.

Conflicts of Interests: None

REFERENCES

[1]. Standring S, Borley NR, Collins P , Crossman AR, Gatzoulis MA, Healy JC, et al. Gray's Anatomy: The Anatomical Basis of Clinical Pra ce.40th ed Philadelphia:Churchill Livingstone Elsevier; 2008.p.409.

[2]. McMinn RMH. Pterygopalatine fossa. In: Sinnatamby CS, ed.Last's Anatomy, Regional and Applied. London: Churchill Livingstone, 1990:451-67.

[3]. Williams PL, Warwick R, Dyson M, et al. The cranial nervesneurology. In: Gray's Anatomy. 37th ed. London: ChurchillLivingstone, 1989:1094-120.

[4]. Moore KL, Dalley AF. Nerves of the face. In: Moore KL, DalleyAF, eds. Clinically Oriented Anatomy. 4th ed. Philadelphia:Lippincott Williams & Wilkins, 1999:832-993.

[5]. Gruber W. [A hook-shaped termed Fortsatzchen over and abovethe infraorbital foramen.] Arc Pathol Anat Physiol Klin Med 1878;72:494-6. German.

[6]. Gozdziewski S, Nizankowski C, Kindlik R. [The morphologicalanalysis of human canalis infraorbitalis and frameninfraorbitale.] Anat Anz 1979;145:517-27. German.

[7]. Bolini P, Del Sol M. [Anatomical considerations of the canal andthe infra-orbital.] Rev Bras Oftal 1990;49:113-6. Portuguese.

[8]. Triandafilidi E, Anagnostopoulou S, Soumila M. [The infraorbitalforamen (the position of the infraorbital foramen in man)].Odontostomatol Proodos 1990;44:87-91. Greek.

[9]. Buckley MJ, Ochs MW. Maxillary osteotomies. Atlas OralMaxillofac Surg Clin North Am 1993;1:53-70.

[10]. McQueen CT, DiRuggiero DC, Campbell JP, ShockleyWW. Orbital osteology: a study of the surgical landmarks.Laryngoscope 1995;105:783-8.

[11]. Chung MS, Kim HJ, Kang HS, Chung IH. Locational relationshipof the supraorbital notch or foramen and infraorbital and mentalforamina in Koreans. Acta Anat 1995;154:162-6.

[12]. Leo JT, Cassell MD, Bergman RA. Variation in human infraorbital nerve, canal and foramen. Ann Anat 1995;177:93-5.

[13]. Aziz SR, Marchena JM, Puran A. Anatomic characteristics ofthe infraorbital foramen: a cadaver study. J Oral Maxillofac Surg2000;58:992-6

[14]. Berry AC. Factors affecting the incidence of non-metrical skeletalvariants. J Anat 1975;120:519-35.

[15]. Bergman RA, Thompson SA, Afifi AK, Saadeh FA. Compendiumof Human Anatomic Variation: Catalog, Atlas and WorldLiterature. Baltimore: Urban and Schwarzenberg, 1988.
[16]. 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;15:88–91.
[17]. Karakas P, Bozkir MG, Oguz Ö. Morphometric measurementsfrom various reference points in the orbit of male Caucasians.Surg Radiol Anat 2003;24:358-62.
[18]. O'Brien J. Proc (Bayl Univ Med Cent). 2004;17(4):418-419.
[19]. Hindy AM, Abdel-Raouf F. A study of infraorbital foramen, canal and nerve in adult Egyptians. Egypt Dent J.1993;39:573-580.
[20]. Varshney R, Sharma N. Infraorbital foramen-Morphometric study and clinical application in adult Indian skulls. Saudi J health Sci 2013;2:151-5.
[21]. Tilak Raj, Anshu Mishra, Parmatma Mishra. Morphometric analysis of infraorbital foramen in north indian skulls.Indian Journal of Basic and Applied Medical Research; December 2014;4(1):185-192.
[22]. Singh R. Morphometric analysis of infraorbital foramen in Indian dry skulls. Anatomy & cell biology. 2011 Mar 1;44(1):79-83.
[23]. Agthong S, Huanmanop T, Chentanez V. Anatomical Variations of the Supraorbital, Infraorbital, and Mental Foramina Related to Gender and Side. JOralMaxillofacSurg. 2005;63:800-804.
[24]. Elias MG, Silva RB, Pimentel ML, Cardoso VTS, Rivello T, Babinski MA.Morphometric analysis of the infraorbital foramen and acessoriesforaminas in brazilian skulls. Int JMorphol 2004;22(4):273-278.
[25]. Macedo VC, Cabrini RR, faig-leite H. Infraorbital foramen location in dry human skulls. Braz JMorphol Sci 2009;26(1):35-38.
[26]. Lopes PTC, Pereira GAM, Santos AMPV, Freitas CR, Abreu BRR,Malafaia AC. Morphometric analysis of the infraorbital foramenrelated to gender and laterality in dry skulls of adult individuals in southern Brazil. Braz JMorpholSci 2009;26(1):19-22.
[27]. Gaur KK, Nair S, Trivedi GN, Guptha SD. Anthropometric measurements of infraorbital foramen in dried human skulls. Int J BiolMedRes 2012;3(3):2003-2006.
[28]. Boopathi S, Chakravarthy Marx S, Dhalapathy S, Anupa S Anthropometric analysis of the infraorbital foramen in a South Indian population Singapore Med J 2010;51(9):730-735.
[29]. Singh R. Morphometric analysis of infraorbital foramen in Indian dry skulls.Anat Cell Biol 2011;44:79-83
[30]. Lokanayaki V. Anatomic variations of infra orbital foramen. CIB Tech Journal of Surgery 2013;2(2): 30-36.
[31]. Malamed SF. Techniques of regional anaesthesia in dentistry.In: Malamed SF, eds. Handbook of Local Anaesthesia. Noida:International Print-O-Pac Ltd, 2006:198-9.
[32]. Bharti A, Puranik MG. Morphometric study of infraorbital foramen in dry human skulls. Natl J Intergr Res Med 2013;4:43-9.
[33]. Ukoha Ukoha Ukoha, Kosisochukwu Emmanuel Umeasalugo, Onochie Okwudili Udemezue, Henry C Nzeako, Godwin U Ndukwe, Perpetua C Nwankwo. Anthropometric measurement of infraorbital Foramen in south-east and south-south Nigeria. National journal of medical research . 2014;4(3).
[34]. Priya Roy P, S D Jadhav, Kumar Sai Sailesh , MA Doshi, and M P Ambali. Morphometric Analysis of Supraorbital and Infraorbital Foramen in Maharastrian Skulls. July– August 2015 Rjpbcs6(4):2036.
[35]. Cutright B, Quillopa N, Schubert W: An anthropometric analysis of the key foramina for maxillofacial surgery. J Oral Maxillofac Surg. 2003;61:354-357.
[36]. Apinhasmit W, Chompoopong S, Methathrathip D,Sansuk R, Phetphunphiphat W: Supraorbital notch/ foramen, infraorbital foramen and mental foramen in Thais: Anthropometric measurement and surgical relevance. J Med Assoc Thai 2006;89:975-2.
[37]. Blanton PL, Jeske AH: The key to profound local anesthesia. J Am Dent Assoc 2003;134(6):753-760.
[38]. Sivavadivel swaminathan et al , localization and morphometric evaluation of supraorbital and infraorbital foramen in dravidian population of southern india: a paleoantropological study on dry skulls**.** Iosr journal of dental and medical sciences (iosr-jdms) 2013;5(4):18-23.
[39]. Oliveria Junior EMD, Moreira RT, Neto BL, Silva CMFD & Lima FJCA. Morphological and biometric study of the infraorbital foramen (E2-Sibai point) in adult skulls. Int. J. Morphol., 2012;30(3):986-992.
[40]. Sinnatamby, C. S. Last's Anatomy Regional and Applied. 10th Ed. Edinburgh, Churchill Livingstone, 1999.
[41]. Ongeti, K.; Hassanali, J.; Ogeng'o, J. & Saidi, H. Biometric features of facial foramina in adult Kenyan skulls. Eur.J. Anat., 2008;21:89-95.
[42]. Ilayperuma Morphometric Analysis of the Infraorbital ForamenIn Adult Sri Lankan Skulls. Int. J. Morphol., 2010;28(3):777-782.
[43]. Alok Kumar Singh Accessory infraorbital foramen and morphometric localization of infraorbital foramen NJIRM 2015;6(5).

How to cite this article: M. Veeramuthu, Ravi varman, Shalini, Manoranjitham. MORPHOMETRIC ANALYSIS OF INFRAORBITAL FORAMEN AND INCIDENCE OF ACCESSORY FORAMEN AND ITS CLINICAL IMPLICATIONS IN DRY ADULT HUMAN SKULL. Int J Anat Res 2016;4(4):2993-3000. **DOI:** 10.16965/ijar.2016.391