Original Article

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Infraorbital Foramen: A Morphometric Analysis in Dry Skulls of Adult Indian Population with its Clinical Implications

Mehandi V. Mahajan[1], Kalpana R.[2], Anupriya Alagesan[3]

Abstract

Aims: 1. To study the morphometric dimensions of infraorbital foramen. 2. To compare the differences with other populations. 3. To study its clinical implications. *Settings and Design*: The data was collected from various medical colleges in Chennai.it was an observational study. *Methods and Material*: Total of 257 (514 sides) dry human adult skulls of unknown age and gender were assessed. The data was collected with help of Vernier caliper, scale, needle & compass. The measurements were performed onthe right and left side of the skull. The study was conducted and the distances were analyzed of infraorbital foramen (IOF) with respect to the infraorbital margin (IOM), supraorbital foramen (SOF), nasion, the nasal rim, the superior alveolar margin (SAM) and the distance from the opposite infraorbital foramen. The height and width of the IOF was also measured. The direction of the infraorbital canal was also noted.The mean and the range was observed and compared with other populations. The data were analyzed statistically. *Statistical Analysis used:* SSPS. *Results*: Mean distances of IOF to Superior orbital foramen [SOF] are 40.2mm and 40.6mm, IOF to Nasion [N] are 42.9mm and 42.8mm, IOF to Nasal Rim [NR] are 16.3mm and 16.4mm, IOF to Infraorbital Margin [IOM] are 7.0mm and 6.9 mm, IOF to Superior Alveolar Margins [SAM] are 25.5mm and 25.4mm on the right and left side respectively. The mean distance of the IOF of one side to the opposite IOF was 50.58mm. Average height & breadth of IOF was3.85mm and 3.65mm on the right and left side respectively. These values were statistically analyzed and also compared with other populations. *Conclusions:* This analytical study gives detailed information of IOF which will facilitate professionals to ascertain the neurovascular bundle and in turn assist in noninvasive & invasive surgical repairs.

Keywords: Infraorbital Nerves; Infraorbital Vessels; Morphometric Data.

Introduction

Infraorbital foramen [IOF] is situated bilaterally on the frontal aspect of the maxillary bone, below the infraorbital margin, varying from 5-10mm and is usually directed infero-medially through which the nerves and vessels of the same name pass [1]. The infraorbital nerve is a continuation of the maxillary nerve which passes through the infraorbital groove and canal to emerge out through the infraorbital formaen. This nerve plays an important role in regional anesthetic blocks for nasal endoscopic surgeries in cases like recurrent sinusitis, nasal polyposis, antrochoanal polyps, sinus mucoceles and excision of selected tumors [2]. These blocks are also useful in oral surgeries for cases such as dentoalveolar abscess, trauma or maxillary and mandibular fractures, pulpitis, or root impaction, orofacial laceration repair (eg- tongue, lip, mucosal), and in postoperative analgesia as well as chronic pain settings [3,4]. The infra orbital nerve and vessels located within the foramen supply important structures such as the inferior eyelid, nasal wing, superior lip and the vestibular gums of the anterior and premolar molar teeth [5]. Any improper techniques can lead to hemorrhages, hematomas and trauma with damages to nerves and vessels. So a proper well defined landmark could help in

Author's Affiliation: [1]Associate Professor, Department of Anatomy, Sri Muthukumaran Medical College, Hospital & Research Institute, Chennai. The Tamil Nadu Dr. M.G.R Medical University, Gunidy, Chennai, Tamil Nadu, India. [2]Professor and Head, Department of Anatomy, Sri Muthukumaran Medical College, Hospital & Research Institute, Chennai. The Tamil Nadu Dr. MGR Medical University, Gunidy, Chennai, Tamil Nadu, India. [3]Assistant Professor, Department of Anatomy, Sri Ramchandra Medical College & RI, Chennai. Sri Ramchandra Medical University, Porur, Chennai, Tamil Nadu, India.

Corresponding Author: Kalpana R., Professor and Head, Department of Anatomy, Sri Muthukumaran Medical College, Hospital and Research Institute, Chennai 600069, Tamil Nadu, India.
E-mail: mm1710@gmail.com

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preventing wrong procedures. Any variations with regards to its position, size , shape and distances from important anatomical landmarks will help in reducing hazards during the operative procedures. A detailed knowledge of these parameters would thus facilitate therapeutic, diagnostic and surgical manipulations during any maxillofacial surgical treatment [6]. There are numerous studies showing marked variation in the morphometry of the infraorbital foramen amongst various different populations and race [7-13]. Thus the aim of present study was to carry out a detailed analysis of the morphometric dimensions of infraorbital foramen in Adult Indian population, compare it with other studies and study its clinical relevance.

Subjects and Methods

A total of 514 infraorbital foraminas [257 on right & 257 on left sides] were studied in dry adult human skulls of unknown age and gender. They were obtained from department of Anatomy of various Medical Colleges in Chennai where they were used for teaching purposes. The inclusion criteria was the use of only adult human skulls and any skulls with deformed, damaged or with multiple foramina were excluded from the study. For measurements, the instruments used were Digital Vernier caliper [0.01mm], Scale, Needle and Divider [Figure 1].

Fig. 1: Instruments

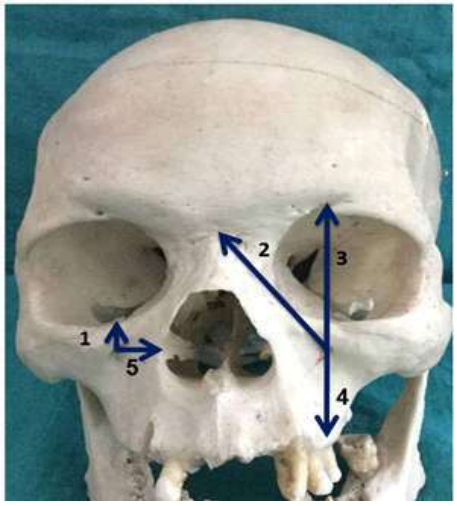

Fig. 2: Points No. 1,2,3,4,5

Fig. 3: Points No. 6

Fig. 4: Points No. 7,8

The following parameters were studied [Figure 2,3,4].

1. Distance between IOF & Infraorbital margin [IOM]
2. Distance between IOF & Nasion [N]
3. Distance between IOF & Supraorbital Foramen [SOF] of the Same side
4. Distance between IOF & Superior Alveloar Margin [SAM] of the Same side
5. Distance between IOF & Nasal Rim[NR]of the Same side.
6. The height [H] and breadth [B] of the IOF alongwith with its shape - oval [O] , round [R] , vertical oval [VO] or horizontally oval [HO] .
7. The direction of the infraorbital canal - Forward, Downward and Medially [FDM] and Forward and Downwards [FD].
8. The tooth at which the IOF vertically corresponds too.

The Mean, Standard Deviation [SD], Students t-test and significance [$p<0.05$] was noted. The SPSS software, 20th version was used for statistical data analysis.

Results

The results obtained in the Present Study are summarised below in the form of tables and figures.

Table 1: Distance between Right and Left IOF with other anatomical landmarks

Distance[mm]	Right [257] Mean[mm]±[SD]	Left [257] Mean[mm]±[SD]	Total [514] Mean [mm]±[SD]
IOF-IOM	7±2.3	6.9±1.7	6.95±2
IOF & SOF	40.2±2.2	40.6±1.9	40.4±2.05
IOF-SAM	25.5±3.9	25.4±3.5	25.45±3.7
IOF-NR	16.3±2.5	16.4±2.7	16.35±2.6
IOF-N	42.9±2.5	42.8±2.3	42.85±2.4

Table 2: Dimension of IOF with regards to Height and Breadth Dimensions of the Infraorbital Foramen

[mm]	Dimensions of the Infraorbital Foramen Right [257] Mean [mm]±[SD]	Left[257] Mean [mm]±[SD]	Total[514] Mean [mm]±[SD]
IOF-Height	3.8±0.8	3.9±1.1	3.85±0.95
IOF-Breadth	3.6±1.1	3.7±1.1	3.65±1.1

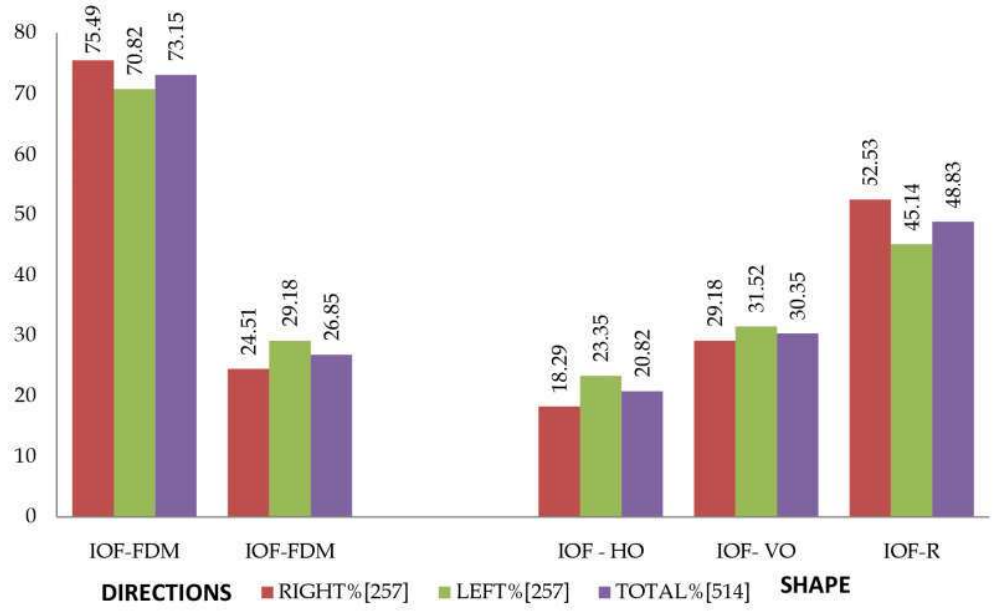

Fig. 5: Frequency of Right and Left IOF with respect to Directions and Shape

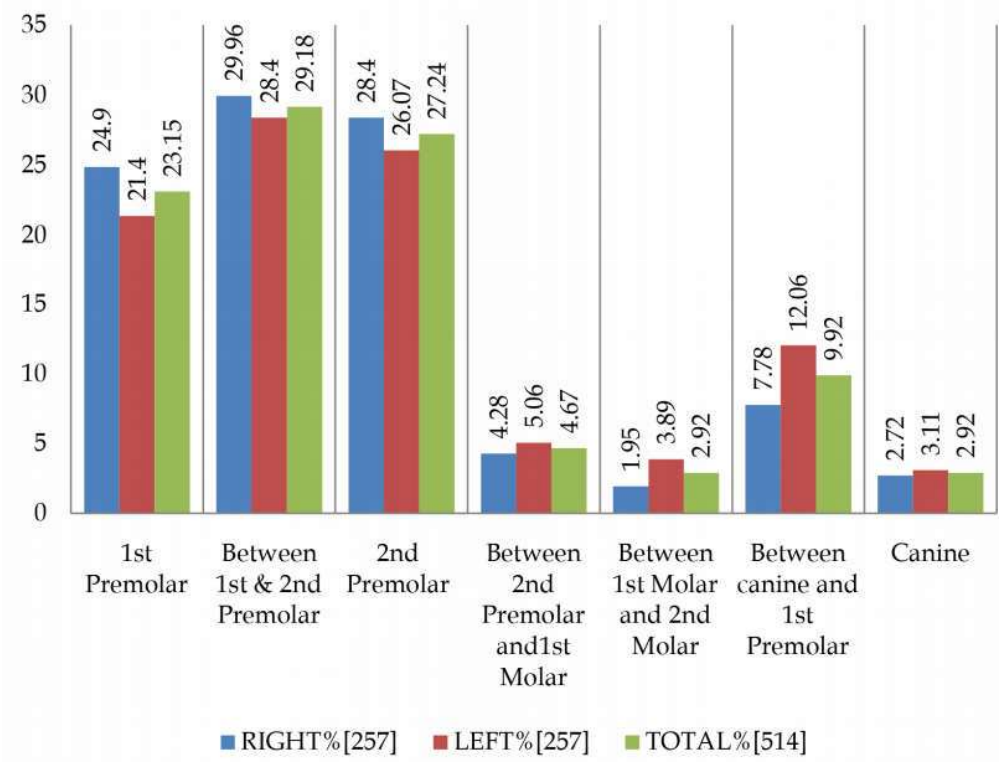

Fig. 6: Percentages of Right and Left IOF with vertically corresponding tooth

Table 3: Comparison between the Present Study and other studies with regards to various parameters

Study	Distance between IOF-IOM Population	Sample Size	Mean±S.D
Present	Tamil Nadu	257	6.95 ± 2
Hwange S H et al[7]	Korea	100	9.6 ±1.7
Ilayperuma I et al[8]	Srilanka	108	9.79±1.66
Ongeti K et al[10]	Kenya	104	6.26±1.75
Aphinhasmit W et al[11]	Thailand	106	9.12±1.87
Aziz et al[12]	Columbia	47	8.15±1.9
Ukoha et al[14]	Nigeria	130	7.38 ± 2.28
Bakirici S et al[15]	Turkey	32	7.32±1.84
Study	**Distance between IOF- SOF Population**	**Sample Size**	**Mean±S.D**
Present	Tamil Nadu	257	40.4±2.05
Ilayperuma I et al[8]	Srilanka	108	44.06±3.49
Aphinhasmit W et al[11]	Thailand	106	44.95±2.96
Aziz et al[12]	Columbia	47	42.75 ±2.75
Tezer et al[16]	Turkey	112	42.75 ±2.75
Study	**Distance between IOF- N Population**	**Sample Size**	**Mean±S.D**
Present	Tamil Nadu	257	42.85±2.4
Nanayakkara D[17]	srilanka	54	42.44±3.4
Przygocka et al[18]	poland	32	44.79±2.98
Singh et al[19]	Uttar Pradesh	64	44.95±4.63
Study	**Distance between IOF- NR Population**	**Sample Size**	**Mean±S.D**
Present	Tamil Nadu	257	16.35±2.6
Saini, Kopal [5]	Maharashtra	100	17.4±2.48
Macedo et al [9]	Brazil	295	17.68±2.07
Hindy AM et al [13]	Egypt	45	14.7 ±2.7

Distance between IOF- SAM

Study	Population	Sample Size	Mean±S.D
Present	Tamil Nadu	257	25.45±3.7
Ongeti K et al[10]	Kenya	104	32.29 ±2.88
Tezer et al[16]	Turkey	112	31.62±3.09
Brando FH et al[20]	Brazil	210	33.4 ±1.7

Average Height of IOF

Study	Population	Sample Size	Mean±S.D
Present	Tamil Nadu	257	3.85 ±0.95
Saini, Kopal [5]	Maharashtra	100	4.25±0.95
Ilayperuma I et al[8]	Srilanka	108	3.4±0.84
Tezer et al[16]	Turkey	112	4.21±0.91
Singh, R[21]	Uttar Pradesh	55	3.57±1.0
Ezzeddin, E et al[22]	Egypt	59	3.39±0.75

Average Breadth of IOF

Study	Population	Sample Size	Mean±S.D
Present	Tamil Nadu	257	3.65 ±1.1
Aphinhasmit W et al[11]	Thailand	106	3.35±0.62
Tezer et al[16]	Turkey	112	3.11±0.62
Nanayakkara D[17]	Srilanka	54	4.16±0.74
Singh, R[21]	Uttar Pradesh	55	3.35±1.3
Ezzeddin, E et al[22]	Egypt	59	3.28±0.98
Chung et al[23]	Korea	124	4.8±1.2

Direction of IOF as FDM

Study	Population	Sample Size	%
Present	Tamil Nadu	257	73.15
Saini, Kopal[5]	Maharashtra	100	53.33
Ilayperuma I et al[8]	Srilanka	108	85.19

Shape of IOF

Shape	Study	Population	Sample Size	%
Round	Present	Tamil Nadu	257	48.83
	Aphinhasmit W et al[11]	Thailand	106	21

Shape of IOF

Shape	Study	Population	Sample Size	%
Round	Present	Tamil Nadu	257	48.83
	Aphinhasmit W et al[11]	Thailand	106	21
	Bakirici S et al[15]	Turkey	32	58.5
	Nanayakkara D[17]	Srilanka	54	15.3
	Singh, R[21]	Uttar Pradesh	55	29
Vertically Oval	Present	Tamil Nadu	257	30.35
	Aphinhasmit W et al[11]	Thailand	106	50
	Nanayakkara D[17]	Srilanka	54	37.47
	Singh, R[21]	Uttar Pradesh	55	42.7
Horizontally Oval	Present	Tamil Nadu	257	20.82
	Aphinhasmit W et al[11]	Thailand	106	29
	Singh, R[21]	Uttar Pradesh	55	28.1

IOF with highest % of corresponding level of superior alveolar tooth

Study	Population	Sample Size	%	Tooth
Present	Tamil Nadu	257	29.18	Between 1st &2nd Premolar
Ilayperuma I et al[8]	Srilanka	108	55	2nd Premolar
Aziz et al[12]	Columbia-c	47	68	1st Premolar
Hindy AM et al [13]	Egypt-c,s	45	50	2nd Premolar
Fabino et al[24]	Brazil-c	32	68	1st Premolar
Rebaz.S.I [25]	Kurdistan	40	40	Between 1st &2nd Premolar

The infraorbital foramina was studied in 257 skulls on both sides of the skull and hence 514 intact foraminas were examined. The linear distances between the IOF and the selected anatomical parameters are shown in the Table 1.The average distances between IOF-N was 42.85mm,IOF-SAM was 25.45mm, IOF-IOM was 6.95mm, IOF-NR was 16.35mm and IOF-SOF was 40.4mm. In the present study, it is found that the distance between IOF and SOF for the right and left side foraminas were highly significant [$p<0.05$]. All other parameters were not significant. The average height was 3.85mm and the breadth was 3.65mm, with no significance between the right and left foramen [Table 2].

The maximum % foramina were directed forwards, downwards and medially [73.6%] followed by 26.8% which were forwards and medially. The direction was noted with the help of the needle. Predominant of the foramens in the present study were round in shape [48.8%] followed by the vertically oval [30.35%] and then horizontally oval [20.82%] [Fig 5]. The percentage of IOF in relation to the maxillary teeth is shown in Fig 6. It was observed that maximum of the IOF corresponded vertically down between the 1st and the 2nd premolar [29.2%], followed by 2nd premolar [27.25%] and then Ist Premolar [23.15%].

Discussion

The importance of anatomical characteristics of facial foramens have increased due to various surgical procedures like endoscopics and reconstructives surgeries. Regional blocking techniques are described in various books, but as the foraminas are inconsistent, hence there are chances of imperfect analgesia [26]. Hence the knowledge of the IOF 's size and location are essential for surgeons and anaethestics which prevents them from guessing their way through the IOF with the needle and damaging the neurovascular bundle. Also there some studies to indicate that there is diversity in the location of the infraorbital foramen with age, side, race and sex [27].

Thus the present study gains utmost importance as it helps in standardising the various morphometric measurements of IOF as well as determining the distances from various anatomical landmarks and with this elaborate information also enabling surgeons and anasthestics to achieve an an effective nerve block.

Interestingly, the distance of IOF location in relation to the Infraorbital Margin, Superior Alveloar Margin, Nasal Rim and Nasion on the right and the left side did not show much difference and were statistically not significant [Table 1] . This helps to conclude that there is a symmetry that is maintained on both sides with respect to these parameters, but on comparing with various other population studies of different geographic location, the study provides information on the racial differences with regards to IOF and various parameters. To support these findings , there are numerous evidences of racial variation amongst different populations with regards to the morphometry, relative position of the IOF and also its relation with the maxillary teeth [10-13,23,28,29].

Infraorbital Margin [IOM] is widely used as an anatomical landmark to ascertain the location of the IOF and wide variations have been documented in different studies. Aziz et al. Columbia [12] have measured the distance of IOF-IOM on 47 cadaveric heads and found the distance to be 8.15± .9mm. A study by Apinhasmit et al. [11] on Thai adult skulls found that the IOF was located 9.23 ± 2.03mm below the infraorbital margin. Thus on comparing the distance between IOF-IOM of the Present study with other studies like Hwange S H et al. [7] Korea, Ilayperuma I et al. [8] Srilanka, and Ongeti K et al. Kenya [10], Apinhasmit et al. [11] Thai , Aziz et al. [12] Columbia, Ukoha et al. [14] Nigeria and Bakirici S. et al. [15] Turkey - a very high significance was noted [$p<0.0001$] Table 3]. This difference among various populations can be attributed to racial difference [8]. Fear of injury to the patient's eye, prevents dentists for giving an infraorbital nerve block [30]. Thus, the knowledge of the distance between the IOF and IOM would help to locate the danger zone during dissection of the fracture of the anterior maxillary wall or in locating infraorbital plexuses which is a risk zone for plastic surgeons [7,8]. It would also help in determining the position of the acupuncture needle as in trigeminal neuralgias [9] and knowing the morphometric variations helps to decrease the risk in orbital surgeries [31].

The average distance between IOF- SOF in the Present study was 40.4±2.05.On comparison with other population studies like Ilayperuma I et al. [8] Srilanka, Apinhasmit et al. [11] Thailand, Aziz et al. [12] Columbia and Tezer et al. [16]Turkey, very high significance was noted [$p<0.0001$] [Table 3]. As it is evident that the comparative studies between various populations do show a difference due to their racial differences, hence emphasizes for a meticulous evaluation of IOF is needed for any operative procedures [10,29].

When comparing the average distance between IOF And Nasal Rim [NR] of the Present study with Saini, Kopal - Maharastra [5], Macedo et al. [7]

Brazil and Hindy AM et al. [13] Egypt: 45; 14.7±2.7 , very high significance was noted [p<0.0001][Table 3]. Also when comparing the average distance between IOF And Superior Alveolar Margin [SAM] of the Present Study- 257; 25.45±3.7 with Ongeti K et al. [10] Kenya 104; 32.29±2.88, Tezer et al. [12] Turkey: 112; 31.62±3.09 and Brando FH et al. [20] Brazil: 210; 33.4 ±1.7, very high significance was noted [p<0.0001] [Table 3]. Kazkayasi M et al. [32] had also conducted an anatomical study on 35 adult bony heads and noted the distance to be 17.23±2.64. Thus it was noted the the data presented different population were not similar and this differences can be attributed to racial difference, their dietary habits and their dentition [10,27,33].

The average vertical height of IOF of the Present study noted was 3.85±0.95; and on comparing with Saini Kopal- Maharastra [5], Ilayperumal et al. [8] Srilanka and Tezer et al. [16] Turkey, very high significance was noted [p<0.0001][Table 3]. The average Breadth of IOF of the Present study was 3.65 ±1.1 and when compared with Aphinhasmit W et al. [11] Thailand,Tezer et al. [16] Turkey and Chung et al. [23] Korea, very high significance was noted [p<0.0001][Table 3]. Dimensions of the foramens are dependent on the thickness of the neurovascular bundle, which may also determine the dosage of the drug needed in the anaesthetic procedure [5].

In the Present study the direction of the IOF was noted to be forward, downward and medially in 73.2% as compared to the Downwards & Forward which was 26.8%. In other studies like the Saini Kopal-Maharastra [5]: 100; 53.33% and Ilayperumal et al. [8] Srilanka: 108;85.19%, maximum direction of IOF was FDM[Table 3]. Hence from the results obtained in the Present study, it can be hypothesised that the direction of the needle for infraorbital nerve block should be superolaterally and Saini Kopal et al. [5] study also concurred with the same. With regards to the shape of IOF, 48.83% were round, 30.35% were vertically oval and 20.82% very horizontally oval out of the 257 skull study. Aphinhasmit W et al. [11] study showed that out of 106 skulls, 21% were round, 50% were vertically oval and 29% were horizontally oval [Table 3]. On comparing both these works, a Very High Significance [p<0.0001] was noted between both the studies.

In the Present study, IOF was in direct vertical line between 1st and 2nd Premolar in 29.2% cases followed by the 2nd Premolar tooth which was 27.2%. Other population studies like Ilayperumal et al. [6] Srilanka, 55% had IOF corresponding to 2nd Premolar, in Hindy AM et al- Eygpt [13] had 50% of IOF corresponding to 2nd Premolar, Fabino et al-Brazil [24] had 68% IOF corresponding to 1st Premolar which was similarly noted in Aziz et al-Columbia study [12] whereas Rebaz. S. I et al- Kurdistan [25] had 40% between 1st &2nd Premolar. Thus this data highlights the racial differences between the Asians, Whites, and Hispanics with regards to the position of the IOF in relation to the maxillary teeth. All this data becomes important whenever planning maxillary sinus surgeries. In Cladwell -Luc surgery, maxillotomy is done above the dental alveolus especially 1st premolar, thus the passage created has external access to maxillary sinus [24]. During such surgeries the most frequent complications are lesions of Infraorbital nerve leading to paresthesia of the facial region [24]. To prevent such hazards the present data can be utilised during surgical procedures.

Externally, the infraorbital foramen is just medial to the intersection of a vertical line from the pupil (when midline) to the inferior border of the infraorbital ridge [4]. Internally, the infraorbital foramen is approached at the intersection of the mucobuccal fold and the junction of 1st and 2nd. So whenever an infraorbital nerve block is given, the lower eyelid, upper cheek, part of the nose, and upper lip is anesthetizesed [4]. So as per the results obtained from the present study, it can also be hypothesised that the best site for the nerve block would be 6.95 mm inferior to IOM, 16.35mm lateral to the nasal rim and the direction of the needle being superolateral.

All these findings need to be further correlated with the cadaveric studies and studies in living subjects by way of CT scan. Studies with regard to accessory foramens and duplicated foramens need to be conducted. Having noted such diverse ethnic variations with regards to other population studies, where in some studies the sample size was low which could lead to one of the reasons of showing variation, hence to bring out more precision and accuracy, huge sample size studies needs to be undertaken in various population studies for better standardisation. Studies with regards to sex and various age groups also to need to be taken into consideration.

Conclusion

As the infraorbital nerve is used to accomplish regional anesthesia in the maxillo-facial region for diagnostic, surgical and other invasive procedures as well as for therapeutic nerve blocks in intractable unresponsive trigeminal neuralgia, the results of the present study may assist surgeons to localize foramina thus facilitating the surgical outcome. These results may also play an important role as newer techniques for minimally invasive surgery are

developed. The diversity in the various parameters with regards to infraorbital foramen may be attributed to race, age, dentition and dietary factors. Our findings also reinforce that there is ethnic variation in the occurrence of infraorbital foramen among different populations.

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