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Morphometric Analysis And Variations In Position Of The Infraorbital Foramen In Goan Population

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Abstract
Background: *This pioneer study on the infraorbital foramina in the Goan population aims to determine its shape, the presence of accessory foramina and its location with respect to anatomic landmarks.*
Materials and Methods: *An observational study was conducted on 49 dry adult human maxillae of Goan origin, 26 of the right and 23 of the left side. Infraorbital foramina shapes were classified and subclassified as circles and ovals respectively and presence of accessory foramina were noted. The position of the infraorbital foramen was measured using a digital vernier caliper.*
Results: *Data collected was analysed using SPSS software version 20. Our findings indicate that even though the parameters measured on the left side were higher than that on the right, the difference was not significant, thus suggesting that the location of the infraorbital foramen is not significantly asymmetrical. The most common shape was found to be circular and the least was oval horizontal. Majority of the accessory foramina located were left sided.*
Conclusion: *In the Goan population, the distance of all the measured parameters were higher on the left side and the infraorbital foramen was closest to the nasal notch and anterior nasal spine as compared to most other populations.*
Keyword*: Infraorbital foramen, infraorbital margin, anterior nasal spine, nasal notch*

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I. INTRODUCTION

The infraorbital foramen (IOF) through which the infraorbital nerve, vein and artery traverse presents anteriorly on the body of the maxilla.[1] The infraorbital nerve which originates from the trigeminal ganglion carries sensory nerve fibres to the inferior eyelid, adjacent cheek, lateral aspect of the nose, maxillary sinus and upper lip. It also renders sensory nerve supply to the gingiva, bone and pulp of the maxillary central incisors, canines, premolars and mesiobuccal root of the first molars.[2]

The three major types of local anesthetic injection are local infiltration, field block and nerve block. The infraorbital nerve (ION) block is administered during routine dental procedures, maxillofacial surgeries, rhinoplasty and in therapy of trigeminal neuralgia.[2,3,4] The infraorbital nerve may be involved in implant procedures, Le Fort I fractures and fractures involving the malar process and orbital floor.[5,6]

The existence of an accessory infraorbital foramen makes this area more complex.[7] Also, knowledge of the position of the infraorbital artery which supplies lower orbital muscles, maxillary sinus, canine and incisor teeth of the upper jaw, medial angle of eye, lacrimal sac, side of nose and upper lip is critical in flap nasal ala reconstruction surgeries.[8] Dermal filler injections in the infraorbital region may cause strokes and blindness due to occlusion of the artery.[9] Thus, knowledge of the precise position of the foramen is of critical importance.

Multiple studies have proven ethnic and population variability in the morphology and position of the infraorbital foramen and lack of this knowledge may lead to potential clinical complications.[10]

Inspite of its surgical importance, there is no evidence in literature on its morphology and position in the Goan population. Thus, the study aims to determine the IOF morphology, the presence of accessory foramina and the IOF position with reference to various anatomical landmarks so as to guide surgeons and minimise complications during various operative procedures on the Goan population.

II. MATERIAL AND METHODS

This observational study was performed on 49 dry adult human maxillae, 26 of the right and 23 of the left side. The maxillae were obtained from the Department of Anatomy, Goa Medical College. The study commenced after approval from the Institutional Ethics Committee & Research Advisory Committee of Goa Medical College. The maxillae were of unknown age and sex with no observable deformity or fractures. Fractured maxillae or maxillae with damage to bony architecture were excluded from the study.

The shape of the left and right infraorbital foramina were observed and classified as oval or circular. The oval shapes were further subclassified based on their direction to the sagittal plane as ovalvertical ovaloblique and ovalhorizontal. Presence of accessory foramina, if any was noted.

To analyse the morphology and position of the infraorbital foramen, the following parameters were measured on both sides with a digital vernier caliper (least count of 0.01 mm):

1) Distance from infraorbital foramen (IOF) to infraorbital margin(IOM) (mm).
2) Distance from infraorbital foramen (IOF) to anterior nasal spine (ANS) (mm).
3) Distance from infraorbital foramen (IOF) to canine fossa (CF) (mm).
4) Distance from infraorbital foramen (IOF) to nasal notch (NN) (mm).

All measurements were taken by one observer to reduce inter observer bias. Additionally, each measurement was recorded thrice to ensure intra observer reproducibility.

Collected data was analysed using SPSS software version 20 and the results were expressed as mean and standard deviation. Independent t-test analysed the difference between right and left foramina. If p value was below 0.05, the difference was considered statistically significant.

III. RESULTS

As depicted in Table 1, the current study indicated IOF – IOM distance on the left side (6.84 ± 1.19 mm) was greater than the right side (6.50 ± 1.70 mm)

On measuring the distance of the IOF to the nasal notch it was 13.97 ± 2.26 mm on the right side and 15.73 ± 2.06 mm on the left.

The anterior nasal spine was at a distance of 32.71 ± 3.63 mm from the infraorbital foramen on the left side and 30.19 ± 3.86 mm on the right side.

The canine fossa was situated 29.54 ± 3.68 mm from the infraorbital foramen on the left side and 27.23 ± 4.33 mm on the right side.

Hence, with respect to the distance of IOF from respective anatomical landmarks, it can be inferred from Table 1 that even though all the parameters measured on the left side were greater than that on the right side, the difference was not statistically significant. This suggests that the location of the infraorbital foramen from the respective anatomical landmarks is not significantly asymmetrical between the left and right sides.

From Table 2, it can be surmised that the morphology of the IOF was circular in 16 right maxillae and 14 left maxillae. Amongst the oval foramina, there were 4 right and 3 left oval vertical foramina present. The ovaloblique foramina also had the same number of 4 right and 3 left. However, oval horizontal was the least predominant with 2 right and 3 left. Only 1 accessory foramen was observed on the right and 2 on left side.

Table 1: Distance of Infraorbital foramen (IOF) from Infraorbital margin (IOM), Anterior Nasal Spine (ANS), Canine fossa (CF) and Nasal notch (NN).

Variable(mm)	Right (mm)	Left (mm)	p-value
IOF –IOM distance	6.50 ± 1.71	6.84 ± 1.19	0.94
IOF-ANS distance	30.19 ± 3.86	32.71 ± 3.63	0.91
IOF-CF distance	27.23 ± 4.33	29.54 ± 3.68	0.83
IOF-NN distance	13.97 ± 2.26	15.73 ± 2.06	0.68

Table 2: Number of maxillae showing various shapes of infraorbital foramen and accessory foramina.

Observation		Right	Left
Shape	Circular	16	14
	Ovalvertical	4	3
	Ovaloblique	4	3
	Ovalhorizontal	2	3
Accessory foramen		1 (3.84 %)	2 (8.69 %)

IV. DISCUSSION

The infraorbital nerve which traverses the infraorbital foramen provides extensive sensory innervation to the skin over the malar area between the lower eyelid and the upper lip and is thus vital in terms of administering regional anesthesia. It is of utmost importance to identify the infraorbital nerves and vessels during surgical interventions on the face and maxillary sinuses. Accurate localisation of the infraorbital foramen is important in dental and maxillofacial surgeries as well as nasal surgeries.

The infraorbital margin is used as an anatomical landmark to locate the position of infraorbital foramen. Boopathi et al,[11] Aziz et al[12] and Apinhasmit et al[13] found the distance to be 6.57 ± 1.28 mm, 8.5 ± 2.2 mm 9.23 ± 2.03 mm respectively. Studies on various populations in Asia, Africa and South America indicate that the distance between IOF & IOM ranges between 6 to 10 mm, with the highest being seen in the Sri Lankan population at 9.79 ± 1.75 mm (Table 7). In the present study on the Goan population the distance of IOF from the IOM was found to be 6.45 ± 1.80 mm. (Table 7).

Table 3: IOF – IOM measurements of different population groups

Authors	Population	Sample size	IOF – IOM (Right) (Mean in mm)	IOF – IOM (Left) (Mean in mm)
Agthong et al [14]	Brazil	110	7.80 ± 0.20	8.00 ± 0.20
Lopes et al [15]	Brazil	99	6.57 ± 1.70	6.76 ± 1.64
Elsheikh et al [16]	Egypt	59	6.37 ± 1.40	
Hwang et al [17]	Korea	100	9.6 ± 1.7	
Ilayperuma et al [18]	Sri Lanka	108	9.79 ± 1.66	
Ongeti et al [19]	Kenya	104	6.26 ± 1.75	
Aphinhasmit et al [13]	Thailand	106	9.12 ± 1.87	
Aziz et al [20]	Columbia	47	8.15 ± 1.9	
Ukoha et al [21]	Nigeria	130	7.38 ± 2.28	
Bakirici et al [22]	Turkey	32	7.32 ± 1.84	
Present Study	Goa, India	49	6.50 ± 1.71	

Table 4: IOF – IOM measurements of previous studies.

Authors	Sample size	IOF – IOM (Right) (Mean in mm)	IOF – IOM (Left) (Mean in mm)
Aziz et al [20]	47	8.30 ± 1.90	8.10 ± 1.90
Elias et al [23]	210	6.71 ± 1.70	6.83 ± 1.83
Macedo et al [24]	295	6.28 ± 1.79	6.45 ± 1.76
Lopes et al [15]	99	6.57 ± 1.70	6.76 ± 1.64
Boopathi et al [11]	80	6.49 ± 1.26	6.65 ± 1.30
Gaur et al [25]	100	6.52 ± 1.79	6.42 ± 1.70
Singh et al [26]	55	6.12 ± 1.79	6.19 ± 1.81
Shaik et al [27]	125	7.06 ± 1.81	7.20 ± 1.71
Lokanayaki et al [28]	100	6.12 ± 1.43	6.53 ± 1.53
Elsheikh et al [16]	59	6.37 ± 1.40	6.70 ± 1.60
Hwang et al [17]	100	9.6 ± 1.7	
Ilayperuma et al [18]	108	9.79 ± 1.66	
Ongeti et al [19]	104	6.26 ± 1.75	
Aphinhasmit et al [13]	106	9.12 ± 1.87	
Aziz et al [20]	47	8.15 ± 1.9	
Ukoha et al [21]	130	7.38 ± 2.28	
Bakirici et al [22]	32	7.32 ± 1.84	
Present study	49	6.50 ± 1.71	6.84 ± 1.19

Table 5: IOF – NN measurements of different population groups

Authors	Population	Sample size	IOF – NN (Right) (Mean in mm)	IOF – NN (Left) (Mean in mm)
Hindy et al [29]	Egypt	45	14.7 ± 2.7	
Mehandi et al [30]	Tamil Nadu	257	16.35 ± 2.6	
Saini et al [31]	Maharashtra	100	17.4 ± 2.48	
Present study	Goa	49	13.97 ± 2.26	13.97 ± 2.26

Table 6: IOF – NN measurements of previous studies.

Authors	Sample size	IOF – NN (Right) (Mean in mm)	IOF – NN (Left) (Mean in mm)
Kazkayasi et al [32]	35	14.31	
Elias et al [23]	210	13.29	
Macedo et al [24]	295	17.68	
Singh [26]	55	15.56	
Shaik et al [27]	125	18.13	
Lokanayaki [28]	100	16.48	
Saini et al [31]	100	17.4 ± 2.48	
Hindy et al [29]	45	14.7 ± 2.7	
Mehandi et al [30]	257	16.35 ± 2.6	
Present study	49	13.97 ± 2.26	15.73 ± 2.06

Table 7: IOF – ANS measurements of different population groups

Authors	Population	IOF – ANS (Right) (Mean in mm)	IOF – ANS (Left) (Mean in mm)
Ukoha et al [21]	Nigeria	29.01 ± 3.59	
Lopes et al [15]	Brazil	34.70 ± 5.63	35.66 ± 3.91
Ekambaram et al [33]	India	36.30 ± 2.26	36.00 ± 2.36
Agthong et al [14]	Thailand	34.8	35.0
Singh [26]	India	36.73 ± 3.11	36.51 ± 3.23
Nanayakkara et al [10]	Sri Lanka	34.25 ± 2.24	34.41 ± 2.00
Present study	Goa, India	30.19 ± 3.86	32.71 ± 3.63

In the present study, the comparison of the distance of IOF from IOM, ANS, and NN on the left side were higher but not significantly, as p value was less than 0.05 for all parameters.This suggests that the location of the infraorbital foramen is not significantly asymmetrical (Table 1).

The present study along with prior studies showed that the IOF-IOM distance on the left side was greater than the right.

Therefore, this investigation emphasizes that the IOF is situated closer to the IOM on the right side than on the left side.

The distance from the IOF to ANS was found to be higher on the left, though not significantly, which is in concurrence with antecedent literature (Table 7). This distance was least in Nigerian and Goan populations thus emphasizing the importance of meticulous preoperative evaluation.

In the present study it was also found that the distance of IOF-CF on the left side was greater (27.23 ± 4.33 mm) than on the right side (29.54 ± 3.68 mm).

The distance between the IOF and the NN in previous studies conducted on different population groups was reported to be between 13 mm to 18 mm which was within the range of the present study. The current research indicated that most common shape of the IOF was circular. Among the oval shaped foramina, oval vertical and oval oblique were more predominant than oval horizontal.

The presence of accessory infraorbital foramina (AIOF) is well documented in literature. Variation in the prevalence of AIOF across various populations has also been reported. An early study was conducted by Gruber who stated that the number of accessory foramina ranged from 1 to 5.[34]

In a study conducted by Kadanoff et al on 1400 skulls, 131 double (9%), 7 triple (0.5%), and 4 cases of more than three (0.3%) accessory foramina were recorded.[35]

Berry[36] observed AIOF in skulls from 4 different regions and the incidence of AIOF was reported to be 6.4% and 8.7% in Myanmar males and females, 12.5% and 7.9% in North American males and females, 18.2% and 12.5% in Mexican males and females and 2.2% and 4.8% in English males and females. In the present study the incidence of accessory infraorbital foramina was 3.84% on the right side and 8.69 % on the left side. Higher incidences have been observed in Indian skulls (16.25%) by Boopathi et al.[11] and in Mexican males (18.2%) by Berry.[36]

The occurrence of AIOF has been shown to vary on either sides of the skulls.[37] Bressan et al.[38] has documented the prevalence of AIOF as 4.7% in Italian population and has also observed that there is a higher prevalence on the left side (2.16%) than the right side (1.22%) which is in concurrence with our observations.

The knowledge of accessory infraorbital foramina is of importance since there could be an accessory branch of the ION passing through. Doubling of the infraorbital vessels and nerves is documented where in both the IOF and AIOF have their respective individual neurovascular bundles.[39, 40]

This observation is of importance for surgeons operating on the face in the infraorbital region to provide adequate local anaesthesia and to prevent injuries to the accessory infraorbital nerve.[39]

The infraorbital nerve block may be administered by an intraoral or an extraoral route and anesthetizes the orbital, buccal and nasal areas[41]. Upon identification of the IOF, the needle can be advanced through the skin directly toward the IOF or from the oral cavity at the height of the mucobuccal fold around the first premolar area. The nerves emerging from the foramen are likely to be damaged during surgeries such as orthognathic surgeries and fixation of Le Fort II fractures which may result in paraesthesia or anesthesia of the areas supplied by the infraorbital nerve. The IOF is also an important reference point in orbital surgeries[42] and a surgical landmark for external access to the maxillary sinus.[43] This study on the location of the IOF and its variations in the Goan population will act as a useful guide in the successful administration of the infraorbital nerve block.

V. CONCLUSION

Our findings indicate that the distance of all the measured parameters were higher on the left side. The IOF of Goan population was closest to the nasal notch and the anterior nasal spine as compared to most other population groups.

These findings are of importance to maxillofacial surgeons and anaesthetists.

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