ORIGINAL RESEARCH

Morphometric study of infraorbital foramen in dry human skulls and its clinical implications

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ABSTRACT:
Background and Objectives: Infraorbital foramen (IOF) is an important anatomical structure that is present on maxillary bone of both sides through which the infra orbital canal provides passage to infra orbital artery, vein and nerve and communicates with the facial structures superficially. Infraorbital nerve block is widely used to achieve regional anaesthesia during surgeries involving the midface region and paranasal sinuses. However, the anatomy of IOF varies between genders and among different population groups. The present study was conducted to study the dimensions, orientation, and position of IOF in relation to different clinically important anatomical landmarks of Indian skull.**Methodology:** The presentstudy was conducted at Anatomy department of our medical college overtwo years fromAugust 2020 to July 2022on skulls of known sex and agewith no apparent gross pathology, deformity, or traumatic lesions. Shape, size, number, direction of opening of IOF as well as distance of IOF from important anatomical landmarks of face were recorded on both sides of the skull.**Results:** 28 dry human skulls or 56 sides were studied. The commonest location was found to be in line with upper second premolar tooth (60.7%) followed by between upper first and second premolar tooth in 23.2%.The most common shape of IOF was oval (42.9%) followed by semilunar (28.6%). The commonest direction of opening of IOF was medially downward (51.8%) followed by medially (33.9%). In majority (73.2%) cases IOF was located lateral to the lateral margin of SOF. Mean vertical and transverse diameter of IOF were 3.16± 0.77 mm and 3.27± 0.78 mm on right side and 3.19±0.76 mm and 3.27±0.77 mm on left side respectively. Mean distance between IOF and IOM was 7.27± 1.48 mm, IOF and PA was 17.07±1.75 mm, IOF and LAM was 25.51±1.93 mm, IOF and SOF was 43.76±4.41 mm, IOF and ANS was 34.96±3.62 mm, IOF and Na was 42.57±4.15 mm. There was no statistically significant difference between males and females among the parameters studied.**Conclusion:** The morphology of IOF is quite variable, so it is essential to perform a meticulous preoperative evaluation of IOF in all patients posted for maxillofacial surgery and regional block anaesthesia. The anatomical landmarks studied could help in near precise localisation of IOF thereby decreasing the risk of failures and complications during procedures.

Keywords: Infraorbital foramen, surgical procedures, dry skulls, local anaesthesia.

Abbreviations: ANS: anterior nasal septum; IOF: Infraorbital foramen; IOM: Infraorbital margin; LAM: Lower border of alveolus of maxilla; NA: nasion; PA: Piriform aperture; SOF: supraorbital foramen; S.D: Standard deviation;

INTRODUCTION

Infraorbital foramen (IOF) is an important anatomical structure that is present on maxillary bone of both sides at approximately 1 cm below theinfraorbital margin (IOM). IOF is basically an opening through which the infra orbital canal provides passage to the infra orbital artery, vein and nerve and communicates with the facial structures superficially.IOF is relatively larger than the supraorbital foramen and is quite variable in morphology and position. Infraorbital nerve (ION) is terminal branch of second division of trigeminal nerve (maxillary nerve) that exits through the IOF. When eye is in forward gaze, this nerve and pupil lie in the same vertical plane.[1]ION is a total sensory nerve that after exiting the IOF branches to innervate skin inupper portion of face, maxillary sinus mucosa,maxillary incisor, canine, premolar teeth and adjoining gums region, lower eyelid skin

&conjunctiva, part of nose as well as skin and mucosa of the upperlip.[2]

ION block is widely used to achieve regional anaesthesia during surgeries involving the midface region and paranasal sinuses.As this nerve is located in close proximity to vital structures of orbit, nose, and buccal regions, it is indispensable for professionals in maxillofacial surgery and regional anaesthesia to have a clear understanding of its precise location so as to perform with ease certain diagnostic, surgical or other invasive procedures without causing procedural neurovascular injuries.[3,4]Moreover, modern era of pain management in pharmacologically unresponsive trigeminal neuralgia requires identification of appropriate landmarks in relation to the neurotomy of infraorbital nerve for pharmacologic or radiofrequency ablation.[5] However, the anatomy of IOF variesbetween genders and among different population groups, more so if an accessory foramen is also present.[6,7]Various soft tissues and bony landmarks have been utilised to determine its precise location, especially infraorbital margin and maxillary teeth but they also didn't yield consistent results.Despite such clinical relevance, information available on the dimensions and relative position of the IOF using Indian skull as reference is scarce. Based on this background, the present study was conducted to studymorphological characteristics of IOF in Indian skulls at a tertiary care level institute.

AIM AND OBJECTIVES

To study the dimensions, orientation, and position of IOF in relation to different clinically important anatomical landmarks of Indian skull.

METHODOLOGY

Study duration: Two years fromAugust 2020 to July 2022

Study setting:deptt of Anatomy of Nalanda Medical College, Patna, Bihar, India.

Study design: institution baseddescriptive study.

Study technique: Skulls of known sex and approximate age from Anatomy and Forensic Medicine department formed the study group. Only those skulls with no apparent gross pathology, deformity, or traumatic lesions were included in this study. Skulls with damage in the orbital and nasal cavity region and those of less than 18 years of age were excluded.Relevant parameters were measured insagittal and transverse planes after stabilising the skull in Frankfurt horizontal plane. Distances were measured on both sides of skull in relation to centreof IOF to infraorbital margin IOM in sagittal plane, Piriform aperture (PA) in transverse plane, lower end of alveolus ofmaxilla along sagittal plane, anterior nasal septum and nasion in oblique plane.Vertical and horizontal diameters of IOF, location of IOF in relations to upper tooth and presence of accessory foramina (if any) was also noted. Shape of the IOF was studied and reported as oval, triangular, semilunar or circular outline. Direction of opening of the infraorbital canal through the anterior surface of the maxilla was also studied and recorded as downward, medial or downward-medial.Relative position of the IOF in relation to the supraorbital foramen or supraorbital notch (SOF/N) was also studied and recorded as lying in the same vertical plane as or lying lateral or medial to this plane. Measurements were first taken withdouble-tipped compass and then vernier callipers were used to measure the distance to nearest 0.1 mm. All measurements were done by the same person to exclude observer bias. Each measurement was done twice and mean of the two values wastaken as the final distance for analysis so as to increase the accuracy of data.

Statistical analysis: Information so collected was tabulated and entered in Microsoft excel sheet and further analysed by SPSS ver.20® software for Windows. Variables were expressed as mean, standard deviation, percentages, proportions or percentiles as appropriate. Pearson's chi-square test was used for comparison of categorical parameters and independent samples' t test for continuous parameters. P-value <0.05 was taken as significant.

OBSERVATION AND RESULTS

Over the 2-year study period,28 dry human skulls or 56 sides (right + left) were studied in detail. Estimated age of these skulls ranged between 40-60 years. Of these, 17 (60.7%) were of male sex and the rest 11 (39.3%) were of female sex. Atleast one IOF was found on both sides in all these skulls, 2 skulls (7.1%) showed an additional accessory IOF on the right side. The commonest location of IOF was found to be in line with upper secondpremolar tooth (60.7%) followed bybetween upper first and second premolar tooth in 23.2% and the least common location was in line with upper first molar (7.1%) as shown in table 1 below.

Table 1: Location of IOF in relation to upper tooth:

Location	Number (n=56)	Percentage
Between upper first and second premolars	13	23.2%
In line with upper second premolar	34	60.7%
Between upper second premolar and first molar	5	8.9%
In line with upper first molar	4	7.1%

Shapes and direction of opening of skull was studied in each side of skull as shown in table 2 below. Overall, the most common shape of IOF was oval followed by semilunar, triangular and round on either side. Similarly, the most common direction of IOF opening was medially downward followed by

medially and then downward.In majority (73.2%) cases IOF was found to be located lateral to the lateral margin of SOF, in 7.1% cases it was located medial to the medial margin of SOF while in 19.6% cases the two foramina were found to be lying in the same sagittal plane.

Table 2: Shapes and direction of IOF opening on both sides of skull:

Shape	On right side (Number, Percentage)	On left side (Number, Percentage)
Oval	13, 46.4%	11, 39.3%
Semilunar	8, 28.6%	8, 28.6%
Triangular	5, 17.9%	5, 17.9%
Round	2, 7.1%	4, 14.3%
Direction of opening of IOF		
Medially downward	15, 53.6%	14, 50.0%
Medially	9, 32.1%	10, 35.7%
Downward	4, 14.3%	4, 14.3%

Dimensions of IOF and its position with respect to other important anatomical landmarks of the skull was studied in detail as summarised in table 3 below. Mean vertical and transverse diameter of the IOF were 3.16± 0.77 mm and 3.27± 0.78 mm on right side and 3.19±0.76 mm and 3.27±0.77 mm on left side respectively. Mean distance between IOF and IOM was 7.27± 1.48 mm, IOF and PA was 17.07±1.75 mm, IOF and LAM was 25.51±1.93 mm, IOF and SOF was 43.76±4.41 mm, IOF and ANS was 34.96±3.62 mm, IOF and Na was 42.57±4.15 mm. There was no statistically significant difference between males and females among the parameters studied.

Table 3: Dimensions and distances of IOF from specific landmarks.

	Males (n=17)	Females (n=11)	P value
Right Infraorbital foramen (values represented as mean± SD in mm)			
Maximum vertical diameter	3.23± 0.75	3.12± 0.68	0.69
Maximum transverse diameter	3.36± 0.76	3.24± 0.74	0.68
Distance between IOF and IOM	7.26± 1.49	6.58 ± 1.31	0.23
Distance between IOF and PA	17.09± 1.79	16.31± 1.72	0.26
Distance between IOF and LAM	25.44± 1.92	24.23± 1.87	0.11
Distance between IOF and SOF	43.71± 4.36	42.87± 4.62	0.63
Distance between IOF and ANS	34.98± 3.65	34.21± 3.48	0.58
Distance between IOF and Na	42.59± 4.12	42.44± 4.15	0.92
Left infraorbital foramen (values represented as mean± SD in mm)			
Maximum vertical diameter	3.28± 0.76	3.17± 0.68	0.70
Maximum transverse diameter	3.44± 0.78	3.21± 0.72	0.65
Distance between IOF and IOM	7.32± 1.51	6.68 ± 1.34	0.25
Distance between IOF and PA	17.01± 1.74	16.47± 1.73	0.28
Distance between IOF and LAM	26.12± 1.94	24.84± 1.89	0.12
Distance between IOF and SOF	43.95± 4.34	42.93± 4.59	0.59
Distance between IOF and ANS	34.85± 3.67	34.93± 3.81	0.56
Distance between IOF and Na	42.56± 4.19	42.32± 4.25	0.89

(ANS= anterior nasal septum, IOF= Infraorbital foramen, IOM= Infraorbital margin, LAM= Lower border of alveolus of maxilla, NA= nasion, PA= Piriform aperture, SOF= supraorbital foramen)

DISCUSSION

The present study was conducted at a tertiary care level institute over human skull to gain further insight regarding dimension and location of infraorbital foramina in relation to important anatomical landmarks. Population specificmeasurements are of paramount importance for precise identification of IOF and/or its contents in therapeutic, diagnostic, anaesthetic and surgical procedures of the maxillo-facial region.

In the present study atleast one IOF was found on either side of skull which is similar to the findings of Chung et al.[8] Literature shows variable rates of occurrence of accessory IOF among different populations. The incidence of an accessory foramen in this study was 7.1% which is comparable to the Indian study of Bharti et al.[9]The presence of accessory foramina and its contents may explain cause of failure of regional anaesthesia in some cases.[10]Furthermore, such accessory foramina mandates caution for surgeons and anaesthetistsfor potential nerveretraction and accidental intraneural injection that can leadto partial/complete neural injury or paraesthesia.In this study, the most common site of IOF was found to be in line with upper second premolar tooth (60.7%)followed by between first and second upper premolarstooth (23.2%). Thus, together these two landmarks can locate true position of IOF in nearly

85% cases.Ilayperuma et al[11]reported the preponderance of same site in nearly 85% of Srilankan skulls. Such close similarity can be attributed to the two races belonging to close geographical areas of Indian subcontinent. IOF was found at the level of firstmolar tooth in 7% cases which although being a rare occurrencehas the potential to lead to either a complicated or failed ION block during regional anaesthesia.The opening of IOF was directed downward and medially in majority of skulls (51.8%). This was quite lower than the finding (85% IOF opening directed medially downward) of Hindy et al[12] but the clinical implication of this difference is unknown except for expected ethnic variations in direction of IOF opening.

Many anatomy textbooks have described that SOF and IOF lie in the same sagittal plane. Though this may be true for western world,the same is not true for persons of Asian origin.[13]Such variation in the location of IOF may be attributed to difference in race, age, dentition, dietary or other unknown factors. In the present study, IOF was found to be located lateral to the lateral margin of SOF in majority of the cases (73.2% cases) and in only 19.6% cases the two foramina were found to be lying in the same sagittal plane.The maximum transverse and vertical diameters of IOF were found to be larger in males as compared to females but this difference was not statistically significant. Such occurrence may be attributed to larger neurovascularbundles traversing through the foramina in males as compared to females. Information regarding skullforamina size and symmetry is important for diagnosing difficult conditions with the help of endoscopy or radiologic imaging studies. Mean distance of IOF from SOF, IOM, pyriform aperture, lower border of alveolus of maxilla, nasion and anterior nasal septum has been reported to be quite variable between different groups and sometimes between males and females.[14,15] However, no statistically significant difference in measured distance was found in the present study between sexes. In this study, mean distance between IOF and IOM was 7.25± 1.48 on the right side and 7.29± 1.46 on the left side.Variation in distance ranging from 2-8 mm has been reported by authors[16] which again justifies the need to conduct such studies in different races and/or ethnic groups.A few of the anatomic landmarks used in previous studies are practically impossible to locate in living human beings though they are readily appreciable in dry human skulls. Hence, in the present study, inferior orbital margin, nasion and anterior nasal septum which can be palpated clinically on a patient were also used as landmarks to locate the IOF.

CONCLUSION

The location of IOF may be variable even in persons of same ethnic group so it is essential to perform a meticulous preoperative evaluation of IOF in all patients posted for maxillofacial surgery and regional block anaesthesia. The anatomical landmarks described in the study could help in near precise localisation of IOF thereby decreasing the risk offailures and complications during clinical procedures.

LIMITATIONS

The present study has few limitations. First, it is an institutional study and so our findings may not be truly reflective of traits of general population. Second limitation is related to the relatively smaller number of skulls available for studying. Third limitation is that these skulls were not studied radiologically.

CONFLICT OF INTEREST

None to declare.

FINANCIAL DISCLOSURE

The authors hereby declare that the present study has not been conducted under any financial assistance.

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