

Morphometric Analysis of the Infraorbital Foramen in Adult Sri Lankan Skulls

Análisis Morfométrico de la Fosa Infraorbital en Cráneos de Singaleses Adultos

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SUMMARY: Evidence supports a clear racial variation in the position of the infraorbital foramen. Therefore detailed knowledge of the population specific data on biometric features of the infraorbital foramen will facilitate therapeutic, diagnostic and surgical manipulations in the maxillo-facial region. The goal of this study was to elucidate the morphological features and precise anatomical position of the infraorbital foramen with reference to surrounding anatomical landmarks in an adult Sri Lankan population. A total of one hundred and eight adult dry skulls were assessed to determine the number, shape, orientation, vertical and transverse diameters of the infraorbital foramen, transverse distance from the infraorbital foramen to the maxillary midline and the zygomatico-maxillary suture and the vertical distance from the infraorbital foramen to the infraorbital rim and supraorbital foramen. The position of the infraorbital foramen was determined in relation to the maxillary teeth and the supraorbital foramen. The findings indicated that the size of the infraorbital foramen and the mean distances from the infraorbital foramen to the maxillary midline, infraorbital rim and supraorbital foramen was significantly larger in males than in females. The modal position for the infraorbital foramen was in line with the long axis of the second upper premolar and the supraorbital and infraorbital foramina were lying in the same sagittal plane only in 24.07 % of the skulls. The results highlight the racial and gender differences of the infra orbital foramen and emphasize the need for meticulous preoperative evaluation of the infraorbital foramen in patients who are candidates for maxillo-facial surgeries and regional block anesthesia.

KEY WORDS: Infraorbital foramen; Morphometry; Sri Lanka.

INTRODUCTION

The infraorbital nerve, a branch of the second division of the trigeminal nerve exits the skull through the infraorbital foramen. The infraorbital foramen is located bilaterally on the maxillary bone inferior to the infraorbital ridge (Williams *et al.*, 2000; Lee *et al.*, 2006). It is relatively larger than the supraorbital foramen and vary in form and position (Berge & Bergman, 2001). The infraorbital nerve is a totally sensory nerve that innervates the skin of the upper cheek, mucosa of the maxillary sinus, maxillary incisor, canine and premolar teeth and adjacent gingivae, the skin and the conjunctiva of the inferior eyelid, part of the nose and the skin and the mucosa of the upper lip (Williams *et al.*; Lee *et al.*).

The infraorbital nerve block is used to accomplish regional anesthesia in the maxillo-facial region for diagnostic, surgical and other invasive procedures (Zide &

Swift, 1998; Aziz *et al.*, 2000). Therapeutic infraorbital nerve blocks are used in intractable and pharmacologically unresponsive trigeminal neuralgia (Lee *et al.*). Knowledge of the precise anatomical location of the infraorbital foramen is important in modern surgical procedures and in defining the optimal locations for anesthetic nerve blocks, which in turn will invariably reduce the relative risks during clinical procedures (Zide & Swift; Karakas, *et al.*, 2003).

A large body of evidence shows a clear racial variation in the morphometry and relative position of the infraorbital foramen among different populations (Hindy & Abdel- Raouf, 1993; Chung *et al.*, 1995; Aziz *et al.*; Kazkayasi *et al.*, 2001; Karakas, *et al.*; Agthong *et al.*, 2005; Apinhasmit *et al.*, 2006; Ongeti *et al.*, 2008). Furthermore, the position of the infraorbital foramen in relation to the

maxillary teeth is shown to be varied among populations (Aziz *et al.*; Kazkayasi *et al.*; Apinhasmit *et al.*). It is also interesting to note that traits such as localization of the facial foramina not only differ between populations of different geographic zones but also within the inhabitants of the same geographic environment (Ari *et al.*, 2005; Ilayperuma *et al.*, 2009).

Despite its significance little is known concerning the morphological details and the location of the infraorbital foramen in Sri Lankans, inhabitants of the South Asian country. Hence, this study was carried out to elucidate the number, shape, dimensions, orientation and position of the infraorbital foramen in relation to the surgically encountered anatomical landmarks in an adult Sri Lankan population.

MATERIAL AND METHOD

A total of one hundred and eight adult dry skulls (70 male and 38 female) collected from the Department of Anatomy, Faculty of Medicine, University of Ruhuna, Sri Lanka, were used for this study. The age group of the cadavers varied between 48-67 years. Both sides of the skulls were assessed and the number, shape, size and orientation of the infraorbital foramen were recorded by direct visual inspection. The presences of multiple foramina were recorded and the most prominent foramen was considered as the primary structure for characterization. The shape of the infraorbital foramen was described as displaying an oval, semilunar or a circular outline. The direction of opening of the infraorbital canal through the anterior surface of the maxilla was recorded as downward, medial or downward medially.

The greatest transverse and vertical diameters of the infraorbital foramen were recorded. The location of the infraorbital foramen was evaluated by the straight transverse distance from the center of the infraorbital foramen to the

maxillary midline and the zygomatico-maxillary suture at the level of the infraorbital ridge and the vertical distance from the infraorbital foramen to the infraorbital rim and supraorbital foramen. All the measurements were recorded using a digital sliding caliper (Mitutoyo, Japan) capable of measuring to the nearest 0.01mm.

The locational relationship of the infraorbital foramen in relation to the upper teeth was recorded as either in line with the longitudinal axis of the upper second premolar or first molar tooth or as lying between the adjacent upper first and second premolars or between second premolar and first molar tooth.

All the measurements were repeated thrice and the mean was taken for further analysis. Furthermore, the measurements were recorded by the same person to minimize the errors in methodology. Results were expressed as mean ± SD and analyzed using the Statistical Package for Social Sciences (SPSS), 15th version. A comparison of the mean values between sides and genders was performed using the t-test. P value < 0.05 was considered statistically significant.

RESULTS

The mean ages of the study subjects (male: 57.5 ± 12.5; female 57.0 ± 10.8) were not significantly different between the genders. All the skulls studied displayed an infraorbital foramen on both sides. A single infraorbital foramen was present in 96.30% and multiple foramina were found in 3.70% of the skulls. Of the skulls that showed multiple foramina, all had ipsilateral double foramina. The infraorbital foramen was oval in 57.41%, semilunar in 31.48% and circular in outline in 11.11% of the subjects. The opening of the infraorbital foramen was pointed downward and medially in 85.19% and downward in 14.80% of the skulls observed.

Table I. Morphometric measurements of the infraorbital foramen between genders.

Measurements	Males	(Mean ± SD) mm	Females (Mean ± SD) mm
Maximum transverse diameter of IOF	3.88 ± 0.89		3.23 ± 1.06*
Maximum vertical diameter of IOF	3.75 ± 0.79		3.05 ± 0.88*
Distance from IOF to MM	30.69 ± 3.43		28.40 ± 2.82*
Distance from IOF to IOR	10.56 ± 1.74		9.02 ± 1.58*
Distance from IOF to ZMS	2.47 ± 1.56		1.76 ± 1.48
Distance from IOF to SOF	44.86 ± 3.35		43.26 ± 3.63*

IOF - infraorbital foramen; MM - maxillary midline; IOR - infraorbital rim; ZMS - zygomatico maxillary suture; SOF - supraorbital foramen. * P < 0.05.

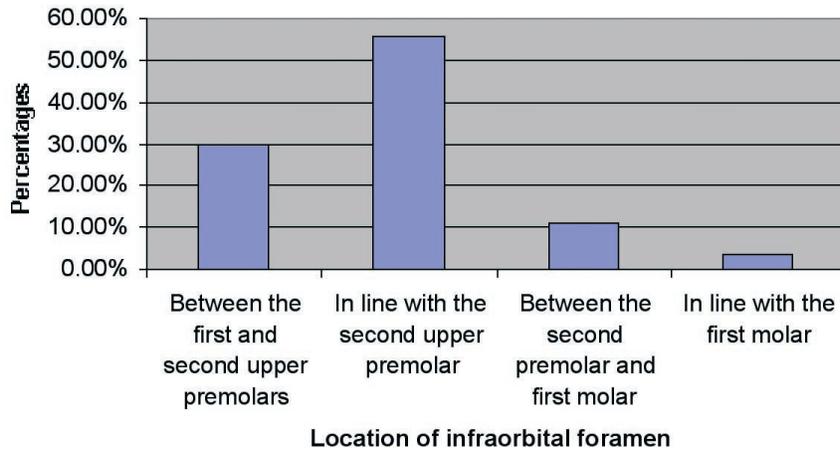


Fig. 1. Frequency of location of infraorbital foramen in relation to the upper teeth.

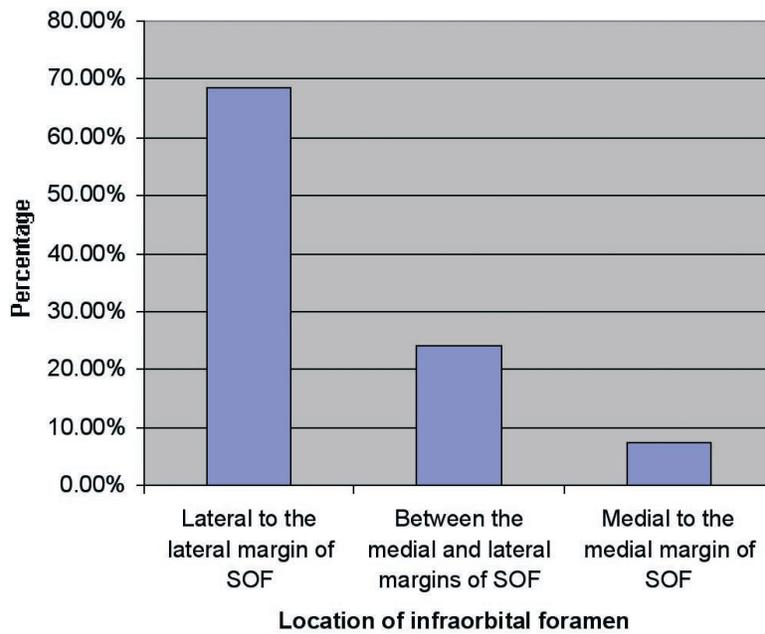


Fig. 2. Frequency of location of infraorbital foramen in relation to the supraorbital foramen.

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

Location of infraorbital foramen	Percentage
Between the first and second upper premolars	29.63
In line with the second upper premolar	55.56
Between the second premolar and the first molar	11.11
In the line with the first molar	3.70

Table III. Frequency of the location of IOF in relation to the position of SOF.

Location of IOF	Percentage
Lateral to the lateral margin of SOF	68.52
Between the medial & lateral margins of SOF	24.07
Medial to the medial margin of SOF	7.41

SOF - supraorbital foramen; IOF - infraorbital foramen.

The anatomical dimensions and the linear measurements of the infraorbital foramen with respect to their surrounding anatomical landmarks are summarized in Table I. These measurements (except the distance between infraorbital foramen and zygomatico maxillary suture) vary significantly ($P < 0.05$) between the genders.

Frequencies of the position of the infraorbital foramen in relation to the upper teeth are shown in Table II and illustrated in Figure 1. The most common position for the infraorbital foramen relative to the upper teeth was found to be in line with the second upper premolar (55.56%), followed by a position between the first and second upper premolars (29.63%). The infraorbital foramen was found between the second premolar and the first molar in 11.11% of the cases and it was located in line with the first molar in 3.70% of the study subjects.

The relative position of the infraorbital foramen in relation to the supraorbital foramen was evaluated (Table III and Figure 2). The most common position for the infraorbital foramen was lateral to the lateral margin of the supraorbital foramen (68.52%). In 7.41% of skulls it was located medial to the medial margin of supraorbital foramen. The two foramina were lying in the same sagittal plane only in 24.07 % of the skulls.

DISCUSSION

The present study provides valuable information on the detailed morphometry and position of the infraorbital foramen in an adult Sri Lankan population. Population specific linear measurements concerning the location of infraorbital foramen will facilitate precise identification of the infraorbital foramen in therapeutic, diagnostic, anesthetic and surgical procedures of the maxillo-facial region (Rossi *et al.*, 2003).

The observation of the present study that the infraorbital foramen was present in all skulls is consistent with previous studies (Chung *et al.*; Apinhasmit *et al.*; Ongeti *et al.*). Evidence shows a wide variation in the occurrence of multiple infraorbital foramina among different populations (Hindy & Abdel-Raouf; Aziz *et al.*; Mangal *et al.*, 2004; Apinhasmit *et al.*; Ongeti *et al.*). The incidence of multiple foramina observed in the present study (3.70%) is consistent with the corresponding figures reported by some studies (Kazkayasi *et al.*, 2003; Apinhasmit *et al.*; Ongeti *et al.*), although it was smaller than the frequencies reported by others (Hindy & Abdel-Raouf; Aziz *et al.*; Kazkayasi *et al.*). Multiple facial foramina have been associated with the

branching of nerves during development and may explain cases of failure during infiltrative anesthesia for maxillofacial procedures (Cutright *et al.*, 2003). Furthermore, the existence of multiple foramina in a minority of patients also has a clinical implication, as injury to any branch of the infraorbital nerve that exit through these foramina, intraneural local anaesthetics or nerve retraction during surgery may result in sensory deficit and partial nerve blockage (Aziz *et al.*).

The transverse and vertical diameters of the infraorbital foramen displayed a significant gender differences which may be attributed to larger neurovascular bundles that traverse the foramina in males compared to females (Ongeti *et al.*). Information concerning the skull foramina size and symmetry is increasingly important with the advancement of endoscopic procedures and radiological techniques such as magnetic resonance imaging (MRI) and computed tomography (CT) that makes difficult diagnoses of pathologic conditions of skull foramina possible (Berge & Bergman; Cutright *et al.*). The opening of the infraorbital foramen was directed downward and medially in majority of the subjects (85.19%). This was in agreement with previous studies (Hindy & Abdel-Raouf; Apinhasmit *et al.*).

The mean distances between infraorbital foramen and maxillary midline, infraorbital rim, supraorbital foramen and zygomatico-maxillary suture were shown to be varied among populations. Furthermore, these variations were clearly demonstrated by comparative studies between White, Black and Hispanic populations (Chung *et al.*; Aziz *et al.*; Cutright *et al.*). The results of this study was in agreement with that of Thais (Apinhasmit *et al.*) although different from those reported for white and Black populations (Aziz *et al.*; Cutright *et al.*), further highlighting the racial differences and emphasizing the need for meticulous preoperative evaluation of the infraorbital foramen in patients who are candidates for maxillo-facial surgeries and regional block anesthesia (Kazkayasi *et al.*).

The mean distances from infraorbital foramen to maxillary midline, infraorbital rim, supraorbital foramen were significantly longer in Sri Lankan males than in females, a result that reinforces the previous observations (Rossi *et al.*; Apinhasmit *et al.*). The gender differences in relative position of the infraorbital foramen emphasize the significance of applying the anatomical variation data to an individual subject in a given population (Agthong *et al.*).

The most common position of the infraorbital foramen in Sri Lankans was in line with the long axis of the second upper premolar (55.56%) followed by a position between the first and second upper premolar (29.63%).

Together, these two positions contribute to an overall prevalence of (85.19%). This is in agreement with the results of previous studies on other Asians (Apinhasmit *et al.*) but different from White, Black and Hispanics where it was found in line with the first premolar tooth (Aziz *et al.*). The results of the present study highlight the racial differences in the modal position of the infraorbital foramen in relation to the upper tooth observed among different populations.

The standard Anatomy texts describe the location of supraorbital and infraorbital foramina on the same sagittal plane (Williams *et al.*; Sinnatamby, 1999). Although this is in accord with some European populations, it ignores a large

body of evidence with reference to other populations (Mwaniki & Hassanali, 1992; Chung *et al.*; Apinhasmit *et al.*). Such diversity in the location of infraorbital foramen may be attributed to race, age dentition and dietary factors (Chung *et al.*; Cutright *et al.*; Ongeti *et al.*). According to the results of this study, the 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 which is consistent with the corresponding figures of Koreans: 38.1% and Thais: 23.4% (Chung *et al.*; Apinhasmit *et al.*). Our findings reinforce the ethnic variation in the occurrence of infraorbital foramen among different populations.

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RESUMEN: En la posición del foramen infraorbitario se evidencia una clara influencia racial. Por tanto, un conocimiento detallado de los datos específicos de la población sobre las características biométricas del foramen infraorbitario facilitará la terapéutica, diagnóstico y manipulaciones quirúrgicas en la región maxilo-facial. El objetivo de este estudio fue, dilucidar las características morfológicas y anatómicas de la posición exacta del foramen infraorbitario, en una población adulta de Sri Lanka, con referencia a los forámenes que los rodean. Un total de 108 cráneos adultos secos fueron evaluados para determinar el número, forma, orientación, diámetros vertical y transversal del foramen infraorbitario, distancia transversal desde el foramen infraorbitario a la línea mediana del maxilar y la sutura cigomático-maxilar y la distancia vertical desde el foramen infraorbitario hasta el margen infraorbitario y al foramen supraorbitario. La posición del foramen infraorbitario se determinó en relación con los dientes superiores y al foramen supraorbitario. Los resultados indicaron que el tamaño del foramen infraorbitario y las distancias medias desde éste a la línea mediana superior, reborde infraorbitario y al foramen supraorbitario fue significativamente mayor en varones que en mujeres. La posición modal para el foramen infraorbitario estuvo en línea con el eje longitudinal del segundo premolar superior, localizándose los forámenes supraorbitario e infraorbitario en el mismo plano sagital sólo en el 24.07% de los cráneos. Los resultados destacan las diferencias raciales y de género del foramen infraorbitario y enfatizan la necesidad de una evaluación preoperatoria meticulosa de este foramen en los pacientes que son candidatos a cirugías maxilofaciales en el bloqueo anestésico regional.

PALABRAS CLAVE: Foramen infraorbital; Morfometría; Sri Lanka.

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