

## MORPHOMETRIC ANALYSIS OF THE INFRAORBITAL FORAMEN AND ACCESSORIES FORAMINAS IN BRAZILIAN SKULLS

ANÁLISIS MORFOMÉTRICO DE LOS AGUJEROS INFRAORBITALES  
Y SUPRANUMERARIOS EN CRÁNEOS DE INDIVIDUOS BRASILEÑOS

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**SUMMARY:** The aim of the study was to establish morphometrically the infraorbital foramen (IOF) location in the sagittal and transversal plan of the skull and to analyze the variations, as well as verifying the symmetry with the contralateral IOF. 210 skulls were analyzed and as exclusion criterion, were not analyzed skulls of children. Digital paquimeter was used and had been carried through two bilateral measures: a) sagittal measure; from infraorbital margin until the superior margin of the IOF; b) transversal measure, of the lateral margin of piriformis opening until the medial margin of the IOF, using the transversal plan. These measures had formed an angle of 90° between itself. The data were analyzed by the Kolmogorov-Smirnov to verify the Gaussian distribution and and Person's test to evaluate the correlation, considering significantly the differences that had presented a  $p \leq 0,05$ . The mean  $\pm$  SD in the sagittal measures were respectively; right side  $6,71 \pm 1.70$  mm and  $6,83 \pm 1.83$  mm for left side ( $p \leq 0.0001$ ). Transversal measures were: right side  $13,28 \pm 2.17$  mm and  $13,31 \pm 2.19$  mm for left side ( $p \leq 0.0001$ ). Were observed supranumerary foramins of the IOF, with presence of the double IOF in 50 cases, being bilateral in 08 specimens, left and right side 21 specimens for each side. The IOF are not absolutely symmetrical and may present pair bilateral and or unilateral opening. The presence of the supranumerary foraminas, as well as, the morphometrics measures in this study may intervene with the anesthesia, thus, suggest that they must be considered in the anaesthetical evaluation and be remembered during the procedures used for the localization of the forame.

KEY WORDS: 1. Skulls; 2. Infraorbital foramen; 3. Infra-orbital foramina; 4. Maxilar bone; 5. Morphometry.

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### INTRODUCTION

The infraorbital foramen (IOF) is situated bilaterally on the maxilar bone, down to the infraorbital border, close 1cm (Gardner *et al.*, 1988; Williams *et al.*, 1989), but there are variations from 4 to 12 mm (Testut & Latarjet, 1954; Bergman *et al.*, 1988). This foramen is directed inferior medial and in it passes the nerve and vessels which have its same name. It has a relatively big diameter if its compared to the supraorbital foramen, and can vary on the form and situation (Testut & Latarjet; Rouvière, 1961; Hollin-shead, 1982; Bolini & Del Sol, 1990; Berge & Bergman, 2001).

Precise knowledge of the location of reference points in this area provides important data in local anesthesia (Zide & Swift 1998) and in maxillofacial and plastic surgical operations (Aziz *et al.*, 2000; Hwang & Baik, 1999; Rontal *et al.*, 1979; Triandafilidi *et al.*, 1990). There are several

reference points on each wall with respect to infraorbital foramen, oral and maxillofacial surgery and local anesthesia (Aziz *et al.*; Du Tolt & Nortje, 2003).

Several studies has been evaluated morphometric assessment of the IOF (Gruber, 1878; Gozdziwski *et al.*, 1979; Bolini & Del Sol; Triandafilidi *et al.*; Ochs & Buckley, 1993; Chapman *et al.*, 1995; Chung *et al.*, 1995; Leo *et al.*, 1995; Aziz *et al.*; Karakas *et al.*, 2002), nevertheless, the results presented large variance. This foramen has been used from various reference points, e.g. to determine the morphometric variations of the orbit (Karakas *et al.*) and variations in size and in symmetry (Bolini & Del Sol; Berge & Bergman), as well as, has been reported the presence of accessory supranumerarios foramins (Gruber; Berry, 1975; Bergman *et al.*; Aziz *et al.*).

Modern surgical procedures (Karakas *et al.*), anesthesia (Zide & Swift), as well as acupuncture practice (Chonghuo, 1993; Chen, 1997; Esper *et al.* 1997,1998), require more precise understanding of the surrounding anatomy (Bolini & Del Sol; Karakas *et al.*). Data on morphometric measurements regarding reference points should reduce risks during procedures, surgical operations and anesthesia (Zide & Swift; Karakas *et al.*; Du Tolt & Nortje). Therefore, the purpose of this study was to conduct morphometric measurements of the IOF location by using the sagittal and transversal plan of the Brazilian skull as reference, as well as verifying the symmetry with the contralateral IOF.

## MATERIAL AND METHOD

The protocol for the present research project has been approved by a suitably ethic committee on human research of Federal Fluminense University and the work complies with the provisions of the declaration of Helsinki in 1995 (as revised in Edinburgh, 2000). Guidelines for our internal review board were met for the observations made herein. Skulls used (210) were all in the collection of two universities of Rio de Janeiro state.

**Morphometric parameters:** To study the landmarks in the IOF, direct measurements were taken from dry Caucasian skulls. The measurements were made with a digital paquimeter (mm). All measurements were performed by the authors. The measurements (bilaterally) on the IOF are shown in Fig. 1.

**Sagittal measure:** a sagittal plain which passes by the center of the IOF, parallel to the median sagittal plain was adopted. With the assistance of a digital paquimeter it was obtained the value of the distance between the infraorbital margin and the superior border of IOF.

**Transversal measure:** a transversal plain that passes by the center of IOF, making a 90° angle with the sagittal plain used for the sagittal measure was adopted and with the assistance of a digital paquimeter it was obtained the value of the distance between the medial border of IOF and the piriformis opening. It was considered the position of the foramen in relation to the zygomatic-maxilar suture, when it crosses the infra-orbital margin. At this point the sagittal plain that passes on it was used to classify the foramen in medial, lateral or on the same direction of this sagittal plain.

The variations of situation and the quantity of opening by IOF were observed.

**Exclusion criterion of the sample:** It was adopted like exclusion criterion all the child skulls and the skulls which the piriformis opening was damaged, unilaterally or bilaterally.

In all the samples the presence of right maxilar joined to the left maxilar was considered indispensable to have the absolutely certainty that the studied foramens belonged to the same original skull and the statistic could express reliable results. The variables age, sex and race were not considered.

**Statistical analysis:** The software Graph Prism was used in the statistical evaluation of measurement results. From these measurements means and standard deviations (mean±SD) were calculated. The data were analyzed by the Kolmogorov-Smirnov to verify the Gaussian distribution and and Person's test to evaluate the correlation, considering significantly the differences that had presented a  $p \leq 0,05$ .

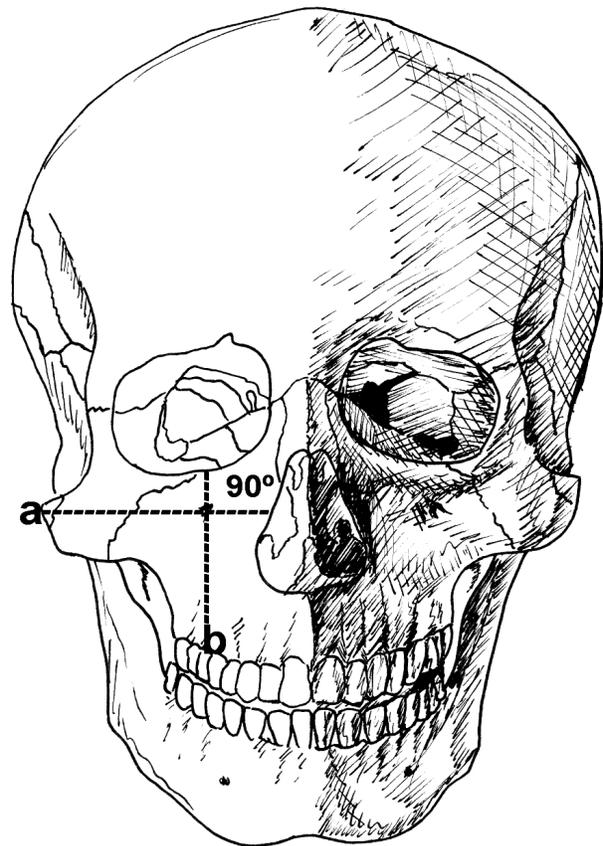


Fig. 1. Schematic draw of the morphometric parameters. a) **Transversal measure:** a transversal plain that passes by the center of IOF and obtained the value of the distance between the medial border of IOF and the piriformis opening making a 90° angle with sagittal measure; b) **Sagittal measure:** a sagittal plain which passes by the center of the IOF, parallel to the median sagittal plain and was obtained the value of the distance between the infraorbital margin and the superior border of IOF;

**RESULTS**

The IOF was present in all the skulls, on the right had sagital measure of  $6,71 \pm 1.70$ mm and transversal measure of  $13,28 \pm 2.17$ mm and on the opposite site the sagital measure was  $6,83 \pm 1.83$ mm and the transversal measure was  $13,31 \pm 2.19$ mm (Table I).

Table I. Morphometric measurements (mm; mean±SD) of the IOFs.

| Plan of measure | Right side       | Left side        |
|-----------------|------------------|------------------|
|                 | Mean ± SD        | Mean ± SD        |
| Sagital         | $6.71 \pm 1.70$  | $6.83 \pm 1.83$  |
| Transversal     | $13.28 \pm 2.17$ | $13.31 \pm 2.19$ |

After having the average and the hypothesis test, it was observed that the foramen of one side had no significant difference in relation to the sagital and transversal measures averages of the opposite side. The Person's test shows the positive correlation ( $r 0.48$ ) between right and left measures ( $p < 0.0001$ ) on the transversal parameter (Fig. 2). On the sagital parameter, it was observed the positive correlation either ( $r 0.52$ ) between the measures on the left side in relation to the right side ( $p < 0.0001$ ) (Fig.3).

Approximately in 99% of the cases, it was observed that foramens obeyed the following relation: if one were medial (in relation to the sagital plain that passed by the zygomatic-maxilar suture when the same crossed the infra-orbital margin) the other was either, or if one were lateral to the to the plain, the other was too. The only exceptions found, in number of 04 foramens, i.e., 02 skulls, in 324 analysed foramens, were of one which was medial to the plain and the other was on the direction of the plain.

After that, the following results of the foramens in relation to the median plain simmetry were found: a) medial (60,25%); b) lateral (08,11%); c) on the plain (30,64%).

The standards of supranumerarios variations of IOF are presented in Table II. In this study, it was identified the opening of IOF was directed inferior medial in 65% (137 cases) of all the analysed skulls. In 35% (73) of all cases, the opening was frontal, without the presence of "rough process" on zygomatic-maxilar suture (Table II).

Table II. Number of infraorbital accessory foraminas in skulls.

| Number of accessory foraminas | Right side | Left side |
|-------------------------------|------------|-----------|
| 1 (normal)                    | 179        | 183       |
| 2                             | 21         | 21        |
| 3                             | 5          | 3         |
| Bilateral                     |            | 8         |
| Total                         | 210        | 210       |

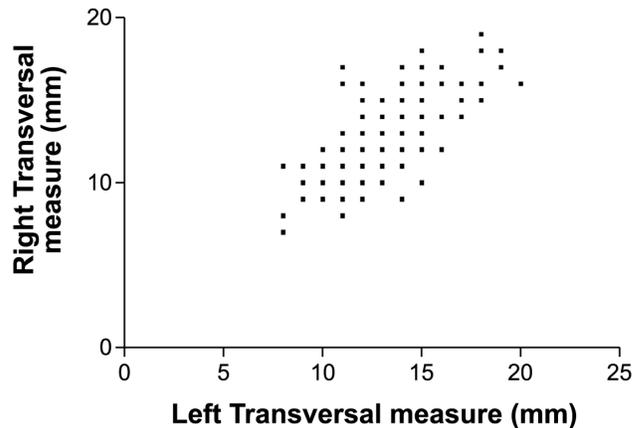


Fig. 2. The graph shows the positive correlation between right and left measures on the transversal parameter.

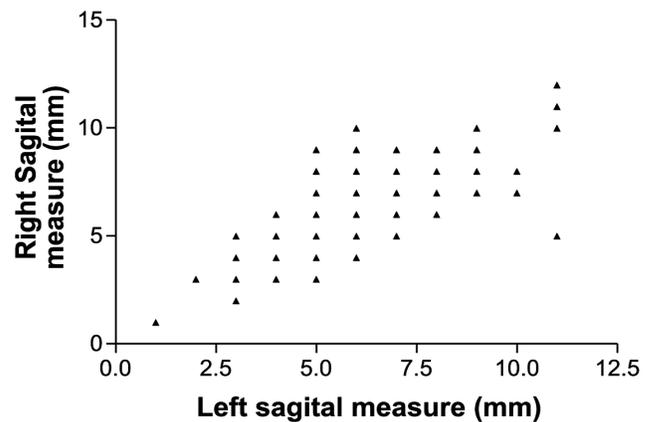


Fig. 3. On the sagital parameter, it was observed the positive correlation either between the measures on the left side in relation to the right side.

**DISCUSSION**

The IOF is the way to the infraorbital nerve, vessels and the knowledge of its position is very useful to the professionals who manipulate the maxilar region, e.g., in acupuncture (E2 point, Sibai) (Chonghuo; Chen; Esper *et al.* 1997,1998), zigoma's fracture surgery (Le Fort II) (Du Tolt & Nortje), practical of intra and extra oral anesthesia (Hollinshead; Dubrul, 1991; Figún & Garino, 1994; Zide & Swift).

The dentist and surgeons of head and neck have to know the exactly position of IOF (Hollinshead; Dubrul; Figún & Garino), because the anesthetic must be put on the foramen in order that it diffuses by the canal and causes the anterior superior alveolar nerve block (that appears on the infraorbital canal of 6,0 to 10,0mm before the infraorbital nerve emerges on the foramen), and in consequence, the block of the branches (which proceed of that nerve) that

supply the central superior incisive teeth, lateral incisive and superior canine, ipsilateral to the blocked nerve (Zide & Swift).

Figún & Garino, point out that, the topography of IOF presents unquestionable interesting on the anesthesia practice of alveolar anterior superior nerve and the infraorbital branch, because the foramen is an excellent reference point to intraoral punctions and extra oral, 5 to 7mm inferior to the infraorbital margin.

Dubrul reported about the variable distance between 6 to 8mm under the inferior margin of the orbit. The authors still contribute to the description of a small “rough process” on the zygomatic-maxilar suture, and may be tangible. Bergman *et al.*, describe a bigger variation, between 3 to 7mm inferior to the infraorbital margin.

The distance between the IOF and midpoint of the inferior orbital margin has been reported to be from 4 mm to over 10 mm in several studies (Hollinshead; Bolini & Del Sol; Triandafilidi *et al.*; Hindy & Abdel-Raouf, 1993; Ochs & Buckley; Chapman *et al.*; Chung *et al.*; Leo *et al.*; Aziz *et al.*; Karakas *et al.*).

Our findings of sagital measure on the studied sample point out to average of 6,71mm on the right side and 6,83 mm on the left side with a minimum of 1mm and maximum of 12mm. Our results show a few extremes and one of them called our attention, because the security margin to anesthetic deposition near the orbit is 1,50 mm (Dubrul). The left sagital measure of 1,00 mm and the right of 1,25 mm was found in a skull that escaped of the security standard. Thus we alert for this type of sporadic case, once more that it was found in only 01 from 210 skulls.

On the inferior wall of the orbit, Rontal *et al.* found the distance between the IOF and midpoint of the inferior orbital fissure to be 24 mm whereas Hwang & Baik found it to be 26mm. Karakas *et al.* pointed that the measurement between the IOF and midpoint of the inferior orbital margin was taken as 7 mm, i.e. similiary with our study, while the distance from the same point to the midpoint of the inferior orbital fissure was 32 mm. There were some differences on the inferior wall measurements between both Indian and Korean skulls (Hindy & Abdel-Raouf; Chung *et al.*).

Monod and Wanverts (in Figún & Garino) located an IOF on a plan (line) which is between the supraorbital incisure and the lip's comissure. According to the literature, there are some standards of location of the foramen on the surface (Dubrul); one of them is to check the line that joins the gengival margin, situated between the central and lateral

incisive, medial to the fronto-zigomatic suture, a reference point easily recognized 4mm over a horizontal line that passes by the lateral angle of eyelid slit. An other classic conduct suggests situate the foramen on a vertical line that joins the supraorbital incisure to the mentonian foramen, 5 to 6mm under the orbital margin. We agree with Dubrul, because this method may vary on the situation.

An other important variable that we considered on the anesthetic valuation is the presence of accessory IOFs, which were studied for the first time by Gruber, who described the presence of 5 independent foramens in the end of the infraorbital canal.

In relation to the presence of accessory foramens we found double foramen in 50 cases, bilaterally in 08 specimens, both sides, 21 specimens for each side (Table II). Poirier (1912 in Bergman *et al.*), checked the presence of 35 double foramens, two triples and one with 4 foramens. In our study it was identified in 58 cases (Table II). It was observed that inferior medial direction may vary to a frontal opening and without the presence of “rough process” on the zygomatic-maxilar suture described by Dubrul. Aziz *et al.* reported multiple ipsilateral foramina were found in 15% (from 47) of cadavers. In the study by Berry, who used skulls from diferent geographic locations, multiple foramina were found in Mexicans. This may be important for surgeons because injury to any branch can result in sensory deficit and partial nerve blockade (Triandafilidi *et al.*; Karakas *et al.*). The number of infraorbital foramina could sometimes be more than one and accessory foraminas have been found in 2–18% of individuals in various populations (Berry; Gozdieswski *et al.*; Bergman *et al.*; Williams *et al.*, 1995).

Information on skull foramina size and symmetry (Del Sol *et al.*, 1989) is increasingly important because of the advancements in radiologic techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). These methods are making difficult diagnoses of pathologic conditions of skull foramina possible (Berge & Bergman). In addition, the presence of accessories foraminas and the morphometric measurements showed in this study may interfere on the infiltrative anesthesia in maxila, so, we suggest that should be considered on the anaesthetic evaluation and remembered during the procedures used for localization of the foramen.

According to Karakas *et al.*, when comparing similar studies in the literature with this study, on average there is a similarity between the sagital measurements and the data from other studies. However, there are some differences in the results of some of the reference point measurements on the transversal measurements. We consider that the diversity

could be a result of factors such as age, sex, race pointed by Hanihara & Ishida (2001) and differences in the reference points which are taken as criteria in the measurements.

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**ELIAS, M. G.; SILVA, R. B.; PIMENTEL, M. L.; CARDOSO, V. T. S.; RIVELLO, T. & BABINSKI, M. A.** Análisis morfométrico de los agujeros infraorbitales y supranumerarios en cráneos de individuos brasileños. *Int. J. Morphol.*, 22(4):273-278, 2004.

**RESUMEN:** El objetivo del estudio fue establecer morfométricamente la localización del agujero infraorbital (FIO) en los planos sagital y transversal del cráneo y analizar las variaciones, así como verificar la simetría con el FIO contralateral. Fueron analizados 210 cráneos de individuos adultos. Utilizamos un paquímetro digital para efectuar las dos mediciones: a) sagital: del borde infraorbital hasta el borde superior del FIO; b) transversal: del borde lateral de la abertura piriforme hasta el bordemedial del FIO, utilizando el plano transversal. Estas mediciones forman un ángulo de 90° entre sí. Los datos fueron analizados por Kolmogorov-Smirnov y prueba de Person para evaluar la correlación, considerando un  $p \leq 0.05$ . La media y  $\pm$  SD en la distancia sagital fueron en el lado derecho  $6,71 \pm 1.70$  mm y en el lado izquierdo  $6,83 \pm 1.83$  mm ( $p \leq 0.0001$ ). Las medidas transversales fueron: lado derecho  $13.28 \pm 2.17$  mm y lado izquierdo  $13.31 \pm 2.19$  mm ( $p \leq 0.0001$ ). Fueron observadas foraminas supranumerarias del FIO, con la presencia del IOF doble en 50 casos, siendo bilaterales en 8 especímenes izquierdos y derechos de la cara, 21 para cada lado. El FIO no era absolutamente simétrico y podía presentar el par bilateral y la abertura unilateral. La presencia de foraminas supranumerarias, como diversas medidas de este estudio, pueden interferir con la anestesia. Así sugerimos considerar estos parámetros en la evaluación anestésica y recordar las variantes durante los procedimientos usados para la localización del agujero infraorbital.

PALABRAS CLAVE: 1. Cráneo; 2. Agujero infraorbital; 3. Morfometría.

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