Morphometric analysis of the infraorbital foramen related to gender and laterality in dry skulls of adult individuals in southern Brazil

Lopes, PTC.*, Pereira, GAM., Santos, AMPV., Freitas, CR., Abreu, BRR. and Malafaia, AC.

Brazilian Lutheran University, Human Anatomy Laboratory,
Av. Farroupilha, 8001, CEP 92425-900, Canoas, RS, Brazil
*E-mail: pclopes@ulbra.br

Abstract

The knowledge of the anatomical variations undergone by the infraorbital foramen (IOF) is important for the blockage of the infraorbital nerve and surgical maxillofacial procedures, as well. This study aims to analyze the morphometric variations of IOF in relation to gender and laterality in dry skulls of adult individuals in the south of Brazil, and the presence of the accessory infraorbital foramen (IOF). Seventy-two (72) male skulls and twenty-seven (27) female skulls were analyzed and used as parameters for the distance from the anterior nasal spine (ANS) to the IOF center; the distance from the lower rim of the orbital cavity to the center of the IOF; the angle from the ANS to the IOF, and the line from the ANS to the IOF. Comparisons were made between genders and sides of the skull, and the statistical analysis was carried out through the Student *t*-test. These results are essential to perform the nervous blockage and the surgical procedures in the periorbital section in order to avoid some damage to the neurovascular structures which cross this foramen.

Keywords: infraorbital foramen, skulls, Brazilian population, morphometry, laterality.

1 Introduction

The infraorbital foramen (IOF) lies in the maxillary bone, lower to the edge of the orbital cavity, and it is bilateral. The infraorbital nerve and vessels run through this foramen. The infraorbital nerve is sensitive and it lengthens the maxillary nerve, which crosses the IOF, and branches to feed the skin in the upper portion of the face; the maxillary sinus mucosa; the maxillary incisor, the canine and premolar teeth and the adjacent gum portion; the lower eyelid skin and conjunctiva; part of the nose, skin and mucosa of the upper lip. Its anatomy varies according to location, shape, size, laterality and incidence of accessory foramens (AZIZ, MARCHENA and PURAN, 2001; BERGE and BERGMAN, 2001; HANIHARA and ISHIDA, 2001; KAZKAYASI, ERGIN and ERSOY, 2001). Previous papers also examined variations regarding genus and different populations (BERRY, 1975; KARAKAS, BOZKIR and OGUZ, 2002; ELIAS, SILVA and PIMENTEL, 2004; AGTHONG, HUANMANOP and CHENTANEZ, 2005; APINHASMIT, CHOMPOOPONG, METHATHRATHIP et al., 2006). The study and acknowledgement of the anatomical variations of the infraorbital foramen are significant in local anesthesia procedures; in the effective blockage of the infraorbital nerve (SALOMÃO, SALOMÃO and SALOMÃO COSTA, 1990; ZIDE and SWIFT, 1998), in the treatment of the trigeminus neuralgia (WILKINSON, 1999) in maxillofacial surgeries (HWANG and BIAK, 1999; AZIZ, MARCHENA and PURAN, 2000), and consequently, in the protection against procedural neurovascular injuries. The IOF study is useful to determine orbital morphometric variations (KARAKAS, BOZKIR and OGUZ, 2002) and in acupuncture (SILVA, JULIANO and YAMAMURA, 1998).

IOF morphometric variation has been widely studied, although these studies show large variations and conflicting data, mainly when they are conducted in relation to some populations, or genus and laterality. Besides, there are no morphometric data of IOF in dry skulls in the population of southern Brazil. This study aims to analyze anatomic variations related to genus and laterality in dry skulls of adult individuals in the south of Brazil and in the presence of accessory infraorbital foramen (IOF).

2 Material and methods

Ninety-nine (99) dry skulls of adult individuals from southern Brazil were used, being that 72 were male skulls and 27 were female skulls belonging to the Human Anatomy Laboratory of the Brazilian Lutheran University. Measurements were carried out by two researchers, separately. Then, a comparison was made and the mean of data was obtained. The measurements were determined by the distance of the anterior nasal spine (ANS) to the center of the IOF; the distance of the lower edge of the orbital cavity to the center of the IOF; the angle between the line from the ANS to the IOF and the line of the horizontal plane which crosses the ANS (Figure 1), the presence of the IOF. A Mitutoyo caliper was used for distance measurement, and the goniometer was used for the angle. All measurements were conducted bilaterally, and data were compared between genera and the right and left sides of the face. Statistical analysis was developed through the Student *t*-test for paired and

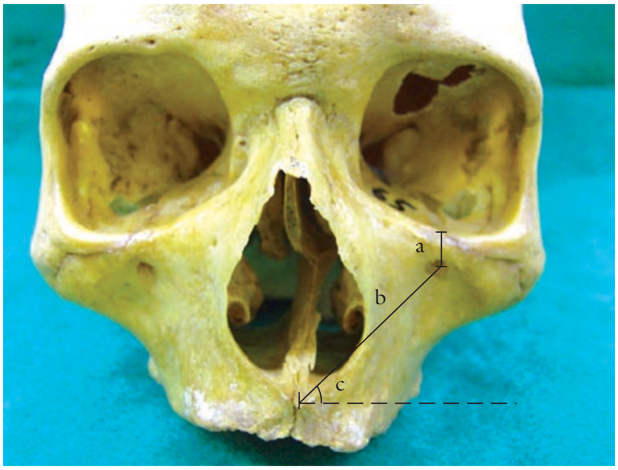

Figure 1. Measurements of the infraorbital foramen. a) distance from the lower edge of the orbital cavity to the center of the foramen; b) distance from the anterior dorsal spine to the center of the foramen; c) angle between b measurement and the line of the horizontal plane which crosses the anterior nasal spine.

independent samples, thus making the significant difference evident when $p < 0.05$.

3 Results

The results of the morphometric measurements of the distance of ANS to the center of the IOF; the distance of the lower edge of the orbital cavity to the center of the IOF; the angle between the line from ANS to the IOF, and the line of the horizontal plane and the presence of IOF are shown in Table 1, 2, 3, 4, 5, respectively.

The comparison of the mean distance results from IOF to ANS (Table 1) show no significant differences regarding laterality in male individuals (A1-A2) between genera, regardless of the side (A5-A6), and between the sides, regardless of the genus (A7-A8). However, there is a significant difference regarding laterality in female individuals (A3-A4; $p < 0.05$). Results of the mean distances from the lower edge of the orbital cavity to the center of IOF (Table 2) do not show significant differences regarding laterality in male individuals (B1-B2), and female individuals (B3-B4), both between genera, regardless of the side (B5-B6), and between the sides, regardless of the genus (B7-B8). As to the angle of the line which goes from the ANS to the IOF and the line of the horizontal plane, regardless of genus, results showed 59.6% on the right side, and 37.4% on the left side (data not shown) for angles between 15° and 35°. No significant difference between genera (Table 3) was evident, regardless of side (C5-C6), although there was a difference ($p < 0.05$) regarding laterality in male individuals (C1-C2), and female individuals (C3-C4). As to the presence of IOF (Tables 4 and 5), the same was absent in most cases in individuals of both sexes (D1 and E3). When present, only a double IOF was found.

3.1 Discussion

A sound knowledge of the characteristics of the foramen and the infraorbital nerve can provide a safer performance of clinical procedures, such as surgeries in the anterior and superior wall of the maxilla; the practice of intra and extra oral anesthesia; surgical treatments, such as rhinoplasty, decrease of the orbital floor, and type 1 Le Fort osteotomies, as well as prevention of related iatrogenic injuries (MOZSARY and MIDDLETON, 1983; LAWRENCE and POOLE, 1992; ZIDE and SWIFT, 1998). The study also applies to the sectional blockage of the infraorbital nerve, regarded as better than infiltration for facial anesthesia, because it accounts for less local tissue edema during surgery, thus allowing for good intrasurgical conditions (MOLLIEX, NAVEZ and BAYLOT, 1996; PRABHU, WIG and GREWAL, 1999).

Previous studies analyzed IOF anatomical variations by checking the distance from the IOF to different reference points, such as the distance to the dental alveolus of the upper second molar (SILVA, JULIANO and YAMAMURA, 1998); to the mean point of the lower orbital fissure (KARAKAS, BOZKIR and OGUZ, 2002); to the lateral edge of the pyriform opening (ELIAS, SILVA and PIMENTEL, 2004); to the rotunda foramen; to the sella turcica, and to the nasion (KAZKAYASI, ERGIN and ERSOY, 2001). In this study the newly-suggested measurement by Agthong, Huanmanop

Table 1. Morphometric measurements (mm; mean ± standard deviation) of the distance from the center of the infraorbital foramen to the anterior dorsal spine.

A1 (72)	34.89 ± 6.26
A2 (72)	35.93 ± 3.96
A3 (27)	34.18 ± 3.50
A4 (27)	34.97 ± 3.74
A5 (144)	35.41 ± 5.24
A6 (54)	34.58 ± 3.61
A7 (99)	34.70 ± 5.63
A8 (99)	35.66 ± 3.91

A1 - distance in male skulls, right side; A2 - distance in male skulls, left side; A3 - distance in female skulls, right side; A4 - distance in female skulls, left side; A5 - distance in male skulls, right and left sides; A6 - distance in female skulls, right and left sides; A7 - distance in male and female skulls, right side; and A8 - distance in male and female skulls, left side.

Table 2. Morphometric measurements (mm; mean ± standard deviation) of the distance from the center of the infraorbital foramen to the orbit lower edge.

B1 (72)	6.64 ± 1.75
B2 (72)	6.87 ± 1.64
B3 (27)	6.36 ± 1.55
B4 (27)	6.46 ± 1.61
B5 (144)	6.76 ± 1.69
B6 (54)	6.41 ± 1.57
B7 (99)	6.57 ± 1.70
B8 (99)	6.76 ± 1.64

B1 - distance in male skulls, right side; B2 - distance in male skulls, left side; B3 - distance in female skulls, right side; B4 - distance in female skulls, left side; B5 - distance in male skulls, right and left sides; B6 - distance in female skulls, right and left sides; B7 - distance in male and female skulls, right side; and B8 - distance in male and female skulls, left side.

Table 3. Angle (°; mean ± standard deviation) between the line which goes from the anterior nasal spine to the infraorbital foramen and the line of the horizontal plane.

C1 (72)	32.51 ± 10.00
C2 (72)	38.28 ± 10.50
C3 (27)	32.44 ± 8.76
C4 (27)	36.22 ± 10.24
C5 (144)	35.40 ± 10.62
C6 (54)	34.33 ± 9.63

C1 - male skulls, right side; C2 - male skulls, left side; C3 - female skulls, right side; C4 - female skulls, left side; C5 - male skulls, right and left sides; and C6 - female skulls, right and left sides.

Table 4. Accessory infraorbital foramen in male and female skulls (n; percentage).

D1 (73)	73.7
D2 (11)	11.1
D3 (6)	6.1
D4 (9)	9.1
n = 99	100

D1 - right and left sides absent; D2 - right side absent; left site present; D3 - right side present and left side absent; and D4 - right and left sides present.

Table 5. Accessory infraorbital foramen in male and female skulls (n; percentage).

E1 (17)	17.2
E2 (9)	9.1
E3 (73)	73.7
n = 99	100

E1 - unilateral; E2 - bilateral; and E3 - neither side.

and Chentanez (2005) was adopted, which uses ANS as a reference point, both for the distance to the IOF and for the measurement of the angle between the line horizontally tangential to the ANS, and the line to the IOF. Different from the anatomical references previously used to locate IOF, such as the line of the mean plane (SILVA, JULIANO and YAMAMURA, 1998), ANS is not affected by the anatomy of nasal bones and cartilages, an anatomy which can show wide individual variations.

The importance of the incidence and lateralization of the IOF is also evident in facial surgical procedures. The recognition of the presence of double or triple foramens is essential when the appropriate amount of anesthesia is applied, or it can be inappropriate. The study of the IOF is also basic to prevent the potential risk for iatrogenic injury during facial surgeries due to the presence of additional branches of the infraorbital nerve (KAZKAYASI, ERGIN and ERSOY, 2001; KAZKAYASI, ERGIN and ERSOY, 2003). In this study the IOF was absent in 73.7% of the investigated skulls. Analysis of laterality pointed to an incidence of 11.1% of the IOF only on the left side, and 6.1% only on the right side. Bilaterality was registered in 9.1% of skulls. The values found by Agthong, Huanmanop and Chentanez (2005) were smaller, with an incidence of 3.6% on the right side, and 4.5% on the left side, although the occurrence of bilateralism was not registered. Equally smaller values were reported by Apinihasmit, Chompoopong, Methathrathip et al., 2006 (2006), where 3.3% of the IOF were double IOF in the Thai individuals' skulls. Kazkayasi, Ergin and Ersoy (2003), found double IOFs in 5.7% of the sides, and only one case of bilateralism in thirty-five analyzed skulls. The study by Elias, Silva and Pimentel (2004) showed a close relationship with the obtained results, at least regarding the incidence of left side double foramens. The incidence of double foramens on the right side was also of 10% of the total amount of skulls in the Brazilian skulls investigated. Hanihara and Ishida (2001), noticed the incidence of IOF in many continents, the Europeans being among the population groups which show the highest frequencies. The obtained results make it possible for the authors to state that standards of difference regarding sex, laterality, and interrelated characteristics are not consistent among the investigated population groups. As to the distance of IOF from ANS (Table 1), results are very close to those by Agthong, Huanmanop and Chentanez (2005), showing a significant difference (A3-A4; $p < 0.05$) regarding laterality of female individuals, and longer mean distances in the male individuals (A1-A2). Regarding the distance of IOF from the lower edge of the orbital cavity, studies have shown measure variation (BOLINI and DEL SOL, 1990; AZIZ, MARCHENA and PURAN, 2000; KARAKAS, BOZKIR and OGUZ, 2002). The results obtained are close to those by Karakas, Bozkir and Oguz (2002), who reported the mean distance of 6.7 ± 1.9 mm in skulls of Caucasian adult male individuals. The mean distances (B7-B8) for the right and the left sides, regardless of genus, are closer to the ones found by Silva, Juliano and Yamamura (1998), in Brazilian individuals' skulls; but they were lower than those by Agthong, Huanmanop and Chentanez (2005), with data of 7.8 to 8.0 mm in skulls of Asian adult individuals. As to the mean distances (B5-B6) obtained for genus, regardless of side, they were similar to those by Cutright, Quillopa and Schubert (2003), with a significant difference between sexes, and lower than the ones obtained in Thay individuals' skulls by Apinihasmit, Chompoopong, Methathrathip et al., 2006 (2006), who reported a mean distance of 9.23 ± 2.03 mm for genus, with a significant difference between female and male skulls. Angle measurements between the ANS drawn line to the IOF and the line of the horizontal plane concerning laterality in male individuals (C1-C2; $p < 0.05$), and female individuals (C3-C4; $p < 0.05$) showed bigger angles than those obtained by Agthong, Huanmanop and Chentanez (2005), but with significant difference, thus suggesting that laterality and not genus has to be accounted for the location and approach of the IOF.

4 Conclusion

Comparison of results from previous studies makes the large variation of the anatomical characteristics of the infraorbital foramen evident, not only due to the diversity of the used parameters, but also due to the distinct investigated populations. With a possibility of these characteristics being dependent on population groups, this study makes the morphometric study of this foramen in the population of southern Brazil relevant. Besides, these results can play a role in the performance of surgical procedures in the periorbital area in order to prevent the involvement of neurovascular structures which cross this foramen.

References

AGTHONG, S., HUANMANOP, T. and CHENTANEZ, V. Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. *Journal of Oral Maxillofacial Surgery*. 2005, vol. 63, no. 6, p. 800-804.

APINHASMIT, W., CHOMPOOPONG, S., METHATHRATHIP, D. et al. Supraorbital notch/foramen, infraorbital foramen and mental foramen in Thais: anthropometric measurements and surgical relevance. *Journal of the Medical Association of Thailand*. 2006, vol. 89, no. 5, p. 675-682.

AZIZ, SR, MARCHENA, JM. and PURAN, A. Anatomic characteristics of the infraorbital foramen: a cadaver study. *Journal of Oral Maxillofacial Surgery*. 2000, vol. 58, no. 9, p. 992-996.

BERGE, JK. and BERGMAN, RA. Variations in size and in symmetry of foramina of the human skull. *Clinical Anatomy*. 2001, vol. 14, no. 6, p. 406-413.

BERRY, AC. Factors affecting the incidence of non-metrical skeletal variants. *Journal of Anatomy*. 1975, vol. 120, no. 3, p. 519-535.

BOLINI, P. and DEL SOL, M. Considerações anatômicas sobre o canal e o sulco infra-orbital. *Revista Brasileira de Oftalmologia*. 1990, vol. 49, no. 2, p.113-116.

CUTRIGHT. B., QUILLOPA, N. and SCHUBERT, W. An anthropometric analysis of the key foramina for maxillofacial surgery. *Journal of Oral Maxillofacial Surgery*. 2003, vol. 61, no. 3, p. 354-357.

ELIAS, MG., SILVA, RB., PIMENTEL, ML. et al. Morphometric analysis of the infraorbital foramen and accessories foraminas in Brazilian skulls. *International Journal of Morphology*. 2004, vol. 22, no. 4, p. 273-278.

HANIHARA, T. and ISHIDA, H. Frequency of discrete cranial traits in major human populations. IV. Vessel and nerve related variations. *Journal of Anatomy*. 2001, vol. 199, no. 3, p. 273-287.

HWANG, K. and BIAK, SH. Surgical anatomy of Korean adults. *Journal of Craniofacial Surgery*. 1999, vol. 10, no. 2, p. 129-134.

KARAKAS, P., BOZKIR, M. and OGUZ, O. Morphometric measurements from various reference points in the orbit of male caucasians. *Surgical and Radiologic Anatomy*. 2002, vol. 24, no. 6, p. 358-362.

KAZKAYASI, M., ERGIN, A., ERSOY, M. et al. A. Microscopic anatomy of the infraorbital canal, nerve, and foramen. *Otolaryngology-Head* & *Neck Surgery*. 2003, vol. 129, no. 6, p. 692-697.

KAZKAYASI, M., ERGIN, A., ERSOY, M. et al. Certain anatomical relations and the precise morphometry of the infraorbital foramen-canal and groove: an anatomical and cephalometric study. *Laryngoscope*. 2001, vol. 111, no. 4, p. 609-614.

LAWRENCE, JE. and POOLE, MD. Mid-facial sensation following craniofacial surgery. *British Journal* of *Plastic Surgery*. 1992, vol. 45, no. 7, p. 519-522.

MOLLIEX, S., NAVEZ, M. and BAYLOT, D. Regional anesthesia for outpatient nasal surgery. *British Journal* of *Anaesthesia*. 1996, vol. 76, no. 1, p. 151-153.

MOZSARY, PG. and MIDDLETON, RA. Microsurgical reconstruction of the infraorbital nerves. *Journal* of *Oral Surgery*. 1983, vol. 41, no. 11, p. 697-700.

PRABHU, KPK., WIG, J. and GREWAL, S. Bilateral infraorbital nerve block is superior to peri-incisional infiltration for analgesia after repair of cleft lip. *Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery*. 1999, vol. 33, no. 1, p. 83-87.

SALOMÃO, JIS, SALOMÃO, JAS and SALOMÃO COSTA RCS. New anatomic intraoral reference for the anesthetic blocking of the anterior and middle maxillary alveolar nerves (infraorbital block). *Brazilian Dental Journal*. 1990, vol. 1, no. 1, p. 31-36.

SILVA, RE., JULIANO, Y., YAMAMURA, Y. et al. Relações anatômicas do ponto de acupuntura E-2 (Sibai) localizado no forame infra-orbital. *Revista Paulista* de *Acupuntura*. 1998, vol. 4, no. 1, p. 19-22.

WILKINSON, HA. Trigeminal nerve peripheral branch phenol/glycerol injections for tic douloureux. *Journal of* N*eurosurgery*. 1999, vol. 90, no. 5, p. 828-832.

ZIDE, B. and SWIFT, R. How to block and tackle the face. *Plastic and Reconstructive Surgery*. 1998, vol. 101, no. 3, p. 840-851.

Received October 8, 2008
Accepted April 14, 2009