Original article

Study of landmarks in dried skulls in a Brazil population

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Abstract

Craniofacial bone variations, considered to be radiological landmarks, have been studied since the beginning of the century using dried skulls and cadavers. These pitfalls are important bone landmarks used in the planning and execution of anesthetic and surgical procedures. The present study analyzed craniofacial bone variations in dried skulls in terms of gender and laterality. Supraorbital foramen (SOF), mastoid foramen (MF), parietal foramen (PF), accessory oval foramen (aOF), anterior ethmoidal foramen (AEF), intermediate ethmoidal foramen (iEF), posterior ethmoidal foramen (PEF), precondylar tubercle (PCT), metopism and sutural bones were assessed in male (n=20) and female (n=11) dried skulls by direct observation and using a Mitutoyo caliper. No statistically significant differences were observed between genders as to SOF distances to the medial nasal prominence and to superior orbital ridge, in both sides of skulls. The same was observed for distances between FP and sagittal line and between FP and lambdoid suture. No multiple foramina were detected. aOF was observed in 80.96% of skulls. Right aEF, iEF and PEF prevailed in female skulls. PCT were seen in 35.5% of female skulls and in 64.5% of male skulls. MF occurrence was higher in right male skulls, and multiple foramina were present in 60% of male skulls (both sides), and in 36.4% of female skulls (both sides). Only one skull presented sutural bone. No metopism was observed. The identification and recording of craniofacial variations is important in the preparation of anesthetic blocks in surgical procedures and in the evaluation of regional neurovascular anatomy, to avoid misinterpretations in planning. This study confirms the existence of significant morphological variations in terms of gender and side in a given population.

Keywords: foramina, landmarks, neurosurgery, dried skull, brazilian population.

1 Introduction

Craniofacial bone variations, considered to be radiological landmarks, have been the object of study since the beginning of the century, using dried skulls and cadavers. They are important in planning and conducting anesthetic and surgical procedures. According to Hanihara and Ishida (2001), discrete cranial characteristics may the consequence of an adaptation process to different environments and survival patterns that depend on aspects like population size and isolation variables. As a result, regional occurrence patterns may evolve.

It is as of surgical planning that surveying and recording these bone variations become important. These efforts may help prevent compromising and injuring neurovascular structures, as in the orbit area, which has connections with the central nervous system, nose, paranasal sinuses, face and structures associated to eye functions (KARAKAS, BOZKIR and OGUZ, 2002). Apart from this, the recording of bone variations in several population groups plays a relevant role in anthropological and evolutionary studies (BERRY, 1975; AGTHONG, HUANMANOP and CHENTANEZ, 2005).

In spite of the large number of bone variations recorded to date, results differ significantly when gender, laterality, race and population groups are compared (BERRY, 1975; WEBSTER, GAUNT, HAMDAN et al., 1986; VASUDEVA and CHOUDHRY, 1996; BERGE and BERGMAN, 2001; HANIHARA and ISHIDA, 2001; KARAKAS, BOZKIR and OGUZ, 2002; CUTRIGHT, QUILLOPA and SCHUBERT, 2003; KESKIL, GÖZIL and CALGÜNER, 2003; AGTHONG, HUANMANOP and CHENTANEZ, 2005; APINHASMIT, CHOMPOOPONG, METHATHRATHIP et al., 2006).

The present study evaluates morphometric variations in supraorbital foramen (SOF), mastoid foramen (MF), parietal foramen (PF), accessory oval foramen (aOF), anterior ethmoidal foramen (AEF), intermediate ethmoidal foramen (iEF), posterior ethmoidal foramen (PEF), as well as the presence of precondylar tubercles (PCT), metopism and sutural bones in dried skulls of men and women.

2 Materials and Methods

In total, 11 dried female skulls and 20 dried male skulls were analyzed. Skulls were obtained from the Laboratory of Human Anatomy, Brazilian Lutheran University, Canoas, Rio Grande do Sul, Brazil. Skulls that in one way or another did not afford perfect observation and measurements, due to damage, were excluded. Records were carried out by direct observation and using a Mitutoyo caliper. In foramina, measurements were always carried out starting from the center. Data were analyzed by descriptive statistics, expressed as means ± standard deviation of mean. The Student's *t* test and the Mann-Whitney test were used to compare measurements of distances. Differences between means were considered significant for $P < 0.05$. The statistical analysis was carried out using the Biostat 5.00™ software.

2.1 Supraorbital foramen (SOF)

The records of SOF occurrence were obtained by direct observation. Shapes were classified as lancet-shaped, oval, rounded, and circular. The relative position of SOF was analyzed based on the distance between the center of foramen and the median nasal line, and on the distance between the center of the foramen and the upper orbital rim. Shapes and distances were recorded for both sides of each skull.

2.2 Mastoid foramen (MF)

Location of MF was recorded based on its position in the temporal bone, in the temporo-occipital suture or on the occipital bone, in both sides of each skull. The existence of more than one smaller foramen near MF was recorded as multiple mastoid foramen (mMF), as described in Berge and Bergman (2001).

2.3 Parietal foramen (PF)

Distances from the center of the foramen to the sagittal line and from the center of the foramen to the lambdoid suture were measured and recorded for both sides of each skull. PF were classified as oval, lancet and circular. Multiple PF were observed.

2.4 Precondylar tubercules (PCT)

The occurrence of saliencies on the anterior margin of the foramen magnum was recorded as unilateral or bilateral.

3 Results

No statistically significant differences were observed in SOF measurements in terms of gender (Table 1). The oval shape was the predominant SOF form in both genders (Table 2). Female skulls revealed the presence of fissures in 9% and 27.3% of skulls, on the right and left sides, respectively. For male skulls, fissures were detected in 15% of the skulls on the right side, and in 10% of skulls on the left side.

Values of PF did not exhibit statistical difference across genders (Table 3). Oval shapes prevailed (Table 4). No multiple PF was recorded in either gender.

aOF was present on the left side in 84.2% of male skulls and in 72.7% of female skulls. On the right side, it was detected in 75% of male and in 91% of female skulls.

MF was recorded on the right (90%) and on the left (85%) sides of male skulls. In female skulls, MF was also observed in both sides (right: 72.7%; left: 81.8%). Location of MF on the temporal bone, the temporo-occipital suture and on the occipital bone is shown in Table 5. mMF were present in 60% of male skulls, on the left and on the right sides, and in only 36.4% of female skulls, also on both sides (Table 6).

All skulls showed AEF and PEF. Also, 38.67% of iEF were on the right side and 48.38% were on the left side. Male skulls presented less iEF than female skulls. Occurrence data concerning gender and laterality are shown in Table 7.

PCT were recorded in 35.5% of female skulls and in 64.5% of male skulls. Considering the presence of PCT in both sides of the skull, it was observed in 35% of male specimens and in only 18.2% of female skulls.

Considering the total number of male and female skulls analyzed, only one male skull presented sutural bone, located medially between the parietal bones and the occipital bones.

No skull analyzed exhibited metopism.

4 Discussion

Location and frequency of SOF was shown to vary considerably across gender and races and, as opposed to a foramen, this notch may be characterized as a

Table 1. Distances (mm) of supraorbital foramen. Data are expressed as mean (X) ± standard error of mean (SEM).

Distances	Female	Male	p
	X ± SEM	X ± SEM	
RML	23.47 ± 1.40 (n=10)	25.39 ± 1.13 (n=16)	0.301
LML	22.04 ± 1.51 (n=9)	24.5 ± 0.75 (n=16)	0.097
SOR R	2.80 ± 0.73 (n=6)	3.71 ± 0.78 (n=8)	0.428
SOR L	2.41 ± 1.04 (n=3)	2.98 ± 0.67 (n=7)	0.657

RML = right medial line distance, LML = left medial line distance, SOR R = distance of center of foramen to the superior orbital rim, right side, SOR L = distance of center of foramen to the superior orbital rim, left side.

Table 2. Supraorbital foramen shape for laterality and gender.

Shape	Female		Male	
	Right	Left	Right	Left
Lancet	33.4%	25%	0	0
Rounded	16.6%	0	0	0
Oval	50%	50%	50%	85.7%
Circular	0	25%	50%	14.3%

Table 3. Distances (mm) of parietal foramen. Data are expressed as mean (X) ± standard error of mean (SEM).

Distances	Female	Male	P
	X±SEM	X±SEM	
SLD R	8.74 ± 1.24 (n=6)	6.99 ± 1.11 (n=10)	0.501
SLD L	7.14 ± 0.92 (n=7)	8.78 ± 2.15 (n=11)	0.927
LS R	32.79 ± 1.38 (n=6)	29.69 ± 1.42 (n=11)	0.179
LS L	26.98 ± 1.85 (n=12)	32.35 ± 1.47 (n=7)	0.062

SLD R = sagittal line distance, right, SLD L = sagittal line distance, left, LS R = lambdoid suture distance, right, LS L = lambdoid suture distance, left.

Table 4. Parietal foramen shape for laterality and gender.

Shape	Female		Male	
	Right	Left	Right	Left
Lancet	0	0	10%	0
Oval	0	20%	0	8.3%
Circular	100%	80%	90%	91.7%

Table 5. Location of mastoid foramen for laterality and gender.

Location	Female		Male	
	Right	Left	Right	Left
Temporal bone	54.5%	54.5%	65%	60%
Temporo-occipital suture	18.2%	18.2%	10%	20%
Occipital bone	0	9.1%	15%	5%

Table 6. Number of multiple mastoid foramina (mMF).

Number	Female		Male	
	Right	Left	Right	Left
1 mMF	27.3%	27.3%	50%	35%
2 mMF	9.1%	9.1%	10%	20%
3 mMF	0	0	0	5%

Table 7. Ethmoidal foramina for gender and laterality: anterior ethmoidal foramina (AEF), intermediary ethmoidal foramina (iEF), and posterior ethmoidal foramina (PEF).

Ethmoidal foramina	Female		Male	
	Right (%)	Left (%)	Right (%)	Left (%)
AEF	100	91	85	85
iEF	63.6	54.6	25	45
PEF	100	91	80	80

fissure (WEBSTER, GAUNT, HAMDAN et al., 1986; CUTRIGHT, QUILLOPA and SCHUBERT, 2003). According to Korey (1980), any foramen in the supraorbital margin and that widens in the orbital cavity is recorded as a SOF. Frontal and supratrochlear foramina are included in this class, though they have also been categorized as hyperostotic foramina (OSSENBERG, 1970; HANIHARA and ISHIDA, 2001). According to Ossenberg (1970), the hyperostotic characters tend to occur more often in males than in females. In the present study, only 15% of male and female skulls exhibited supraorbital fissure instead of SOF, in both sides (72.7% of female and 90% of male skulls presented SOF).

Keskil, Gözil and Calgüner (2003) observed supraorbital fissure in 65% of skulls the authors analyzed. According to Apinhasmit, Chompoopong and Methathrathip et al. (2006), 50% of skulls studied presented bilateral fissures, 17% had bilateral foramina, and 33% of skulls presented fissures on one side and foramina on the other. Agthong, Huanmanop and Chentanez (2005) reported that frequencies of SOF and supraorbital fissures were identical; however, the presence of this kind of fissure was more often recorded on the right side, as opposed to SOF. Apart from this, the authors also concluded that SOF and fissures were absent in 5.5% and 10% of skulls, considering the right and the left side, respectively. Absence records were similar for both genders. Of the total number of skulls analyzed by Apinhasmit, Chompoopong and Methathrathip et al. (2006), 66.5% and 33.5%, respectively, presented supraorbital fissure and SOF. SOF distances and the absence of a significant relationship between right and left sides in terms of gender agree with the data obtained by Agthong, Huanmanop and Chentanez (2005). Also, Apinhasmit, Chompoopong and Methathrathip et al. (2006) reported similar values for measurements, though the authors observed statistically significant differences across genders, with male skulls having larger values.

In the present study, all skulls presented PF, differently from what was reported by Berge and Bergman (2001) and Keskil, Gözil and Calgüner (2003). These authors observed the absence of this foramen in 20% and 37% of the skulls studied, respectively. Keskil, Gözil and Calgüner (2003) reported a higher number of parietal foramina, accompanied or replaced by one single median foramen (sagittal), in 5% of skulls.

aOF was present in 84.2% of the skulls evaluated, though Abd Latiff, Das and Sulaiman et al. (2009) report the presence of this foramen in only one of the 30 skulls of a Malaysian the authors investigated.

The results obtained concerning laterality of MF were similar to those published by Berge and Bergman (2001), as well as the predominance of mMF on the right side. Keskil, Gözil and Calgüner (2003) observed emissary mastoid foramina in 78% of skulls. Of that percentage, 88.5% were located in the temporo-occipital suture.

In the present study, intermediate ethmoidal foramina were named as described by Atherino (2002), although some authors call it double or triple anterior ethmoidal foramina (BERGE and BERGMAN, 2001) or median ethmoidal foramina (WARWICK and WILLIAMS, 1995). Here, all skulls presented AEF and PEF, and 48.38% of skulls exhibited iEF. Berge and Bergman (2001) report that 7% of AEF were double foramina, while 0.5% were triple foramina. Atherino (2002) observed that 5% of orbits investigated had iEF. Rontal, Rontal and Guilford (1979) observed that 25% of the sample had more than one PEF. Caliot, Plessis and Midy et al. (1995) reported the presence of only PEF and AEF in 81% of the sample analyzed, one single AEF in 2%, three foramina in 16.5% and four foramina in only one skull.

Here, 54% of skulls presented PCT, 35% of which in female skulls and 64.5% in male skulls. Vasudeva and Choudhry (1996) reported that 14% of skulls had PCT (5.3% in male and 8.7% in female skulls). Keskil, Gözil and Calgüner (2003) detected PCT in 3.5% of the skulls investigated.

Of the total number of skulls investigated, only one male skull (3.2%) had only one sutural bone, medially located, between parietal and occipital bones. This finding differs from what was reported by Keskil, Gözil and Calgüner (2003), who reported the presence of sutural bones in 7.5% of skulls. Wafae, Ruiz and Pereira et al. (2007) observed sutural bones in 36% of skulls, of which 39% were unilateral bones and 18% bilateral. In 16% of skulls with sutures, bones were medial.

Metopism, which was not observed in the sample of skulls analyzed in the present study, was detected in samples analyzed by Keskil, Gözil and Calgüner (2003) (9%) and Berge and Bergman (2001) (2% of the samples).

5 Conclusion

The present study demonstrates the existence of significant morphological variations in craniofacial structures. The variations observed were related to laterality and gender, though they also depend on the populational group studied. The identification and recording of craniofacial variations is important in the preparation of anesthetic blocks in surgical procedures and in the evaluation of regional neurovascular anatomy, to avoid misinterpretations in planning. This study confirms the existence of significant morphological variations in terms of gender and side in a given population.

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