Morphometrical analysis of supraorbital foramen in dry skulls from Paraíba

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Abstract

Introduction: The supra-orbital foramen is located in the upper portion of the orbit, about 2.5 cm from the midline, allowing the passage of the supra-orbital artery and nerve to the frontal region of the face. The supraorbital neurovascular bundle is often found in a large number of surgical procedures. Thus, our objective was to analyze the morphometry of the supra-orbital foramen and its clinical and surgical implications in the procedures performed in the frontal region.

Material and Methods: One hundred and one dry male and female adult human skulls from the Paraíba State University collection were used for the study. Morphometric variables were bilaterally measured using a 150mm Digital Stainless® Caliper.

Results: The SOF-FZS showed values of 26.3 ± 3.7 and 26.64 ± 4.4 in male skulls, 27.9 ± 3.1 and 26.1 ± 2.3 in female skulls on the right and left sides, respectively. The SOF-TCFB presented values of 22.1 ± 4.4 and 23.2 ± 4.8 in male skulls, 23.5 ± 3.9 and 21.81 ± 3.4 in female skulls, on the right and left side, respectively. SOF-TD showed values of 3.3 ± 1.3 and 3.9 ± 0.6 in male skulls, 3.2 ± 1.3 and 4.3 ± 1.3 in female skulls on the right and left side, respectively.

Conclusion: After analysis, it is possible to infer that the supraorbital foramen morphometry showed statistically significant differences in the SOF-FZS, SOF-SOM and SOF-TD values, which makes this data extremely important for health professionals during local anesthetic procedures for frontal lifting, blepharoplasty and other craniofacial surgeries.

Keywords — supraorbital foramen; morphometry; morphometric analysis.

I. INTRODUCTION

The supraorbital foramen (notch in 75% of cases) is present in the orbit upper portion about 2.5 cm from the midline and can be felt on palpation. Such structure pierces the superciliary arch in the pupillary midline at about one third of the distance from the medial aspect of the orbital margin, allowing the passage of the supraorbital artery and nerve to the frontal region of the face [1]. This foramen allows the supraorbital nerve passage which is sensitive and is responsible for the innervation of a large part of the frontal region including the upper eyelid, forehead and scalp to the lambdoid suture, thus being widely used for local nerve block. The supraorbital neurovascular bundle is often found in a large number of surgical procedures, such as open and endoscopic eyebrow elevations and other facial aesthetic surgeries [2].

In this context, the knowledge of the anatomical variations in supraorbital structures is of great clinical importance when performing surgical and local anesthetic procedures, as well as the application of dermatological substances, such as botulinum toxin, avoiding damage and consequent complications to the nerves and underlying vessels, as they can result in functional and aesthetic disorders for the individual [3]. The knowledge of the anatomical profile of this area in our population is also intended to guide and improve the anatomical knowledge of the supraorbital region avoiding complications during interventions performed in this area, which can provide security to obtain the best results, as well as being basis for comparison in future studies.

Given the above, the study aimed to analyze the morphometry of the supraorbital foramen in dry skulls from Paraíba and its clinical and surgical implications in procedures performed in the face frontal region.

II. MATERIAL AND METHODS

One hundred and one dry adult male and female human skulls were used for the study. The skulls were analyzed in anatomy ossuaries from Paraíba universities laboratories, between October and December 2018.

The skulls were bilaterally measured using the Stainless® digital caliper with a 150 (one hundred and fifty) millimeters capacity. In this study, the parameters studied were: the distance between the medial margin of the supraorbital foramen and the facial midline (SOF-FM); the distance between the supraorbital foramen and the frontozygomatic suture (SOF-FZS); the vertical distance between the inferior margin of the supraorbital foramen and the superior orbital margin (SOF-SOM); the distance between the lateral margin of the supraorbital foramen and the temporal crest of the frontal bone (SOF-TCFB); the maximum transverse diameter of the supraorbital foramen (width, SOF-TD); the maximum vertical diameter of the supraorbital foramen (height, SOF-VD).

Damaged, fractured, deformed or abnormal skulls were excluded from the study. Data were analyzed using Graph Pad Prism version 5.0 statistical software, GraphPad Software, Inc. San Diego CA. Descriptive statistics with mean and standard deviation measurements were used. Inferential statistics was used to compare the variables means for laterality and dimorphism, using the t test. The Shapiro-Wilk test was previously used to verify the variables normal behavior. To reject the null hypothesis, we adopted p <0.05. Graphical data representations were obtained from Microsoft Excel 2016.

III. RESULTS

The results show that the SOF-FZS variable was significantly higher on the left side in male skulls and did not show asymmetry in females. SOF-SOM was significantly higher for the right side in male skulls, whereas in female skulls this variable revealed that the left side was significantly larger. The SOF-FM, SOF-TCFB, SOF-TD and SOF-VD measurements showed symmetry between the right and left sides of the forehead for the same sex. While male SOF-SOM was significantly higher for the right side when compared with this same variable and same side for females, the SOF-TD measure shown the opposite and was significantly higher for the female left side when compared with the same side from male skulls (Table 1).

Table 1. Comparative morphometric analysis between the variables means studied between same sex hemifaces and between sexes of the supraorbital foramen in dry human skulls from Paraíba.

Variables	Male		Female		
	Vmin - Vmáx	Mean ± SD	Vmin - Vmáx	Mean ± SD	P value
SOF-FM					
Right	21.5 – 38.3	29.9 ± 4.6	21.3 – 41.4	27.8 ± 5.3	0.24
Left	15.4 – 34.8	28.08 ± 0.9	22.6 – 34.5	28.9 ± 3.8	0.55
P value		0.09		0.57	
SOF-FZS					
Right	18.8 – 35.8	26.3 ± 3.7	16.9 – 35.6	26.64 ± 4.4	0.83
Left	21.3 – 33.8	27.9 ± 3.1	22.1 – 30.3	26.1 ± 2.3	0.08
P value		0.04*		0.65	
SOF-SOM					
Right	0.8 – 6.9	3.5 ± 1.8	0.7 - 4	2.2 ± 0.9	0.03*
Left	0.7 – 5.2	2.8 ± 1.2	1.4 – 6.3	3.4 ± 1.6	0.2
P value		0.02*		0.04*	
SOF-TCFB					
Right	12.4 - 33	22.1 ± 4.4	12.9 – 32.8	23.2 ± 4.8	0.48
Left	16.2 – 30.4	23.5 ± 3.9	15 – 25.8	21.81 ± 3.4	0.20
P value		0.103		0.303	
SOF-TD					
Right	1.8 – 5.8	3.3 ± 1.3	2.4 – 4.8	3.9 ± 0.6	0.16
Left	0.8 – 6.1	3.2 ± 1.3	2.5 – 6.8	4.3 ± 1.3	0.02*
P value		0.69		0.19	
SOF-VD					
Right	1.8 – 3.5	2.6 ± 0.4	2.4 – 3.3	2.6 ± 0.29	0.91
Left	1.9 – 3.3	2.6 ± 03	2.2 – 3.2	2.7 ± 0.33	0.65
P value		0.56		0.22	

Vmin – Minimal value; **Vmáx** – Maximum value. **SD** – Standard deviation.
*p< 0,05 after applying the Mann Whitey test to compare nonparametric means.
SOF-FM-distance between medial margin of supraorbital foramen and facial midline, SOF-FZS-distance between supraorbital foramen and photozygomatic suture, SOF-SOM-vertical distance between inferior margin and upper orbital margin of supraorbital foramen, SOF-TCFB-distance between the supraorbital lateral margin foramen and the temporal crest of the frontal bone, SOF-TD-the maximum transverse diameter of the supraorbital foramen (width), SOF-VD-the maximum vertical diameter of the supraorbital foramen (height).

The skulls were evaluated according to the supraorbital foramen types, and in this context, 41.07% of the supraorbital foramen present in male skulls and 71.11% of the supraorbital foramen present in female skulls were bilateral supraorbital notches (Fig. 1B). The other most frequent types appeared in 33.92% of the male skulls and were the unilateral accessory foramen type (Fig. 1H) and in and 30.35% of the foramen in male skulls were notch and unilateral foramen (Fig. 1E). The other types and frequencies are indicated and measured in figure 1 and table 2, respectively.

Table 2. Comparative analysis between supraorbital foramen types sexually stratified.

SUPRAORBITAL FORAMEN TYPES	MALE		FEMALE	
	N	*f*	N	*f*
Unilateral Supraorbital Notch	0	0%	1	2,22%
Bilateral Supraorbital Notches	23	41.07%	32	71.11%
Unilateral supraorbital foramen	1	1.78%	1	2,22%
Bilateral supraorbital foramen	14	25%	18	40%
Unilateral notch and foramen	17	30.35%	3	6.66%
Notch and foramen (opposite sides)	1	1.78%	0	0%
Accessory bilateral foramen	2	3.57%	5	11.11%
Unilateral accessory foramen	19	33.92%	9	20%
Absent	3	5.35%	0	0%

N – Total of cases. *f* – Absolut frequency.

Figure 1. Analysis of supraorbital notches and foramen types in dry human skulls.
A - Unilateral supraorbital notch; B - Bilateral supraorbital notches; C - Unilateral supraorbital foramen; D - Bilateral supraorbital foramen; E - Unilateral supraorbital notch and foramen; F - Unilateral notch and contralateral supraorbital

foramen (with accessory); G - Accessory bilateral supraorbital foramen; H - Unilateral accessory foramen; I - Missing supraorbital foramen and foramina.

Our results were compared with other studies for a better analysis of their values. Some studies did not specify gender or side, so they had empty spaces in their gap (Table 3).

Table 3. Comparison of the mean distances found in our study and in different populations, as reported in previous studies.

Studies (year)	Place	SOF-TD (mm)		SOF-VD (mm)		SOF-FM (mm)		SOF-FZS (mm)		SOF-TCFB (mm)		SOF-SOM (mm)	
		Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Ashwini, et al. (2012)	Sul da índia	5.17	5.58	3.5	3.04	22.24	22.20	29.34	28.70	-	-	-	-
Nanayakkara, et al. (2018)	Sri Lanka	2.75	3.02	1.49	1.91	23.48	22.96	28.21	28.07	27.34	27.21	2.60	2.31
Gupta T. (2008)	Índia	4.8	4.5	-	-	23.7	24.1	-	-	29.3	30.1	2.7	2.4
Apinhasmit, et al. (2006)	Tailândia	-	-	-	-	25.14		-	-	26.57		3.15	
Ongeti, et al. (2008)	Quênia	4.85 (M) 4.61 (F)	4.24 (M) 4.11 (F)	-	-	27.31 (M) 26.77 (F)	27.12 (M) 26.89 (F)	-	-	-	-	-	-
Bjelakovic, et al. (2016)	Sérvia	1.55	1.77	-	-	21.9		27.5		26.0		5.33	4.98
Chrcanovic, et al. (2011)	Brasil	-	-	-	-	26.43	27.52	-	-	24.32	22.81	-	-
Sheikh, et al. (2013)	Egito	5.9 (M) 4.1 (F)	5.5 (M) 4.9 (F)	-	-	20.9 (M) 20.0 (F)	21.7 (M) 20 (F)	-	-	-	-	-	-
Cheng, et al. (2006)	China	-	-	-	-	25.33		-	-	-	-	-	-
Chung, et al. (1995)	Coréia	-	-	-	-	2.7		-	-	-	-	-	-
Our study	Brasil	3.3 (M) 3.9 (F)	3.2 (M) 4.3 (F)	2.6 (M) 2,6 (F)	2.6 (M) 2.7 (F)	29.9 (M) 27.8 (F)	28.08 (M) 28.9 (F)	26.3 (M) 26.64 (F)	27.9 (M) 26.1 (F)	22.1 (M) 23.2 (F)	23.5 (M) 21.81 (F)	3.5 (M) 2.2 (F)	2.8 (M) 3.4 (F)

SOF-TD - the maximum transverse diameter of the supraorbital foramen (width), SOF-VD - the maximum vertical diameter of the supraorbital foramen (height), SOF-FM - distance between medial margin of supraorbital foramen and facial midline, SOF-FZS - distance between supraorbital foramen and photozygomatic suture, SOF-TCFB - distance between the supraorbital lateral margin foramen and the temporal crest of the frontal bone, SOF-SOM - vertical distance between inferior margin and upper orbital margin of supraorbital foramen, F- female, M- male.

IV. DISCUSSION

The orbit superior portion is formed by the orbital process of the frontal bone and the minor wing of the sphenoid bone. About 2.5 cm from the midline there is a small structure at the bony edge that can be felt on palpation, the supraorbital notch (found as foramen in 25% of cases). It pierces the superciliary arch at the pupillary midline about one third of the distance from the medial portion of the orbital margin [1].

In the supraorbital notch or foramen pass the supraorbital nerve and vessels. The supraorbital nerve from the trigeminal nerve ophthalmic division runs through the SON/SOF and divides into medial and lateral branches responsible for the upper eyelid, skin and scalp innervation. The supraorbital artery is a branch of the ophthalmic artery from the internal carotid artery, leaving the orbit through the SON/SOF, dividing into superficial and deep branches to irrigate the upper eyelid, forehead and scalp. The supraorbital vein joins the supra-trochlear vein close to the medial angle of the eye to form the facial vein [4].

Several authors have studied the supraorbital foramen types [2, 5-7]. In the study by Nanayakara et al. [2], notches were found in 55.1% of the skulls analyzed. Our study revealed the presence of unilateral notch in 41.07% of male skulls and in 73.33% of female skulls unilaterally and bilaterally, respectively. Thus, the presence of the supraorbital outlet as a foramen and not as a notch has repercussion on the vessels that pass through them.

In a case of foramen, the supraorbital neurovascular bundle is relatively fixed in relation to the skull and, therefore, is more likely to be stretched during retraction. In addition, upon exiting the foramen, the neurovascular bundle will be found in a relative higher position than the superior orbital border and, therefore, deserves caution in those populations where the foramen incidence is high [6]. Higher or lower outputs may predispose to injury during blind procedures performed at the beam exit site, leading to repercussions as hemorrhage, paresthesia, and pain in these vessels the pathways.

Regularly all fibers of the neurovascular bundle exit through the supraorbital foramen or notch. However, some fibers may detach from the main branch within the orbit and exit separately through the accessory foraminen. According to a study by Gupta [7], of the 79 skulls studied, nine had supraorbital accessory foramen (five on the right side and four on the left side). In our study, this foramen was found in 35 skulls, mostly found unilaterally. The presence of these additional outlets indicates that the supraorbital nerves can in some cases branch off within the orbit and these branches then exit through additional openings. This fact may be responsible for incomplete analgesia after injection in classical anatomical sites [5].

The SOF-TD measurement has been evaluated in other studies [2, 4, 6 -13] which obtained mean values of the foramen transverse diameter studied in different populations, namely India [4], Kenya [10] and Egypt [12]. In these three populations the values ranged from 4.61mm to 5.17mm in the right foramen and 4.11mm to 5.58mm in the left side. On the study by Bjelakovic et al. [13] the population of Serbia demonstrated an avarage foramen with a smaller diameter, with a mean of 1.55 mm and 1.77 mm on the right and left sides, respectively. In our study, an average of 3.3 mm to 3.9 mm for the right side was observed in male and female skulls, respectively, and 3.2 mm and 4.3 mm between the male and female left sides, respectively. These results showed that left SOD-TD in women is significantly larger than the same side in males ($p < 0.05$), and that the foramen in the Brazilian and Serbian population have smaller transverse diameter when compared to the same diameters of other studies.

According to Tomaszewska et al. [3] foramen with smaller diameters have a smaller space for the passage of the neurovascular bundle. A smaller diameter in the supraorbital foramen may lead to decreased irrigation, drainage and tenderness of the lateral area of the upper eyelid and skin of the forehead lateral portion, neurovascular bundle passage area, resulting in hypoesthesia or anesthesia, as well as necrosis or ischemia predisposing to hair loss [4]. Here, we seek to analyze morphometric parameters related to supraorbital foramen, comparing laterality and dimorphism values, which characterize the regional population. Therefore, in our population, there is a greater tendency for the development of hypoesthesia and anesthesia in left and male hemifaces.

Regarding SOF-FM, a large variation was presented among the populations of India [2], Sri Lanka [2], Thailand [9], Kenya [10], Serbia [13], Brazil [11], Egypt [8, 12], China [6] and Korea [8], with values ranging from 20.9mm to 27.31mm and 21.7mm to 27.12mm on the right and left sides, respectively. In our study, we found mean values of 27.8 mm and 29.9 mm for the right side, respectively for female and male, as well as 28.08 mm and 28.9 mm for the left side, female and male, respectively. These apparently different values showed no significant differences when comparing the same side between the sexes and both sides in the same sex ($p > 0.05$), revealing bilateral and similar symmetrical measurements between the sexes, but with an average above the compared populations.

According to Nanayakkara et al. [2] this anatomical area is used by some surgeons as a landmark for the location of the supraorbital vessels outlet, in order to avoid procedures in this area, freeing these structures from lesions that can generate necrosis and anesthesia in the regions supplied by these vessels. Thus, procedures of this nature in our study population do not require special attention to any anatomical structure that could show up with some important variation.

Studies characterizing SOF-FZS are scarce. According to surveys conducted in populations from South India [4], Sri Lanka [2] and Serbia [13], it was possible to observe an average of 27.5mm to 29.34mm in the right and left sides. In our study, we found lower average values for the right side, 26.3 mm and for the left side an average of 27.9 mm. These averages showed statistically significant differences, revealing an asymmetry between the right and left sides of male SOF-FZS.

Regarding SOF-TCFB measurement studies in Sri Lanka [2], India [7], Thailand [9], Serbia [13] and Brazil [11] found average values ranging from 22.81mm to 30.1mm. In our study, mean values of 22.1 mm to 23.2 mm were found in male and female right sides respectively and 23.5 mm and 21.81 mm in male and female left sides respectively. Although there is an apparent gender-related difference between sides, these averages did not reveal statistically significant differences, signaling bilateral symmetry between sides and between sexes.

According to Ashwini et al. [4], the frontozigomatic suture is considered an efficient reference point for the supraorbital foramen location compared to the frontal bone temporal crest, as it is an easily palpable place on the skin. Knowing these distances in different populations is important to prevent neurovascular bundle injuries by those who perform forehead and eyebrow surgeries, which are very common in dermatological substances application, such as botulinic toxin [3].

V. CONCLUSION

After analysis, it is possible to infer that the supraorbital foramen morphometry showed statistically significant differences in the SOF-FZS, SOF-SOM and SOF-TD variables between the right or left sides and between males and females of the study population. This knowledge is of importance for health professionals during local anesthetic procedures, frontal lifting, blepharoplasty and other craniofacial surgeries, in order to avoid nerve or vascular injuries, which may have negative repercussions for patients. In addition to this class of professionals, the present study brings contributions in the area of archaeological and forensic anatomy helping in the differentiation of bodies through the knowledge of these dimensions in different populations.

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