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Osteometric Analysis of the Greater Palatine Foramen in Dry Skulls with Dentulous and Edentulous Superior Alveolar Arches in a Brazilian Sample

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ABSTRACT

Introduction: the aim of the present study was to analyze osteometric aspects regarding the location of the greater palatine foramen (GPF) in dry human skulls with dentulous and edentulous superior alveolar arches A cross-sectional study was performed with seventy-five dry skulls, of which, 23 were classified as dentulous and 52 as edentulous. Eligible skulls were photographed in a standardized fashion and analyzed on Image J. Analyzes were performed considering different sides of skulls with the same dental condition (only dentulous or only edentulous) and on both situations, simultaneously. Also, comparisons were performed between the same sides of skulls with different dental conditions (dentulous versus edentulous). For all analyzes, a 95% confidence interval and a 5% significance level were considered. Despite several variables presented statistically significant results ($p<0.05$), the small differences indicated that, if skulls are dentulous or edentulous, the antimeres were symmetric. Edentulous skulls showed larger GPF on the lateromedial axis than dentulous skulls. The GPF was slightly closer to the craniometric point oralis in edentulous skulls.

Keywords: Greater palatine foramen, Hard palate, Asymmetry, Dentulous, Edentulous.

Introduction

The greater palatine foramen (GPF) is located on the hard palate on the angle between the horizontal plate of the palatine bone and the alveolar process of the maxilla, near the upper third molar and anteriorly to the lesser palatine foramen. The greater palatine neurovascular bundle, which is composed by the greater palatine nerve and vessels (artery, vein and lymphatics) passes through the GPF[1-3].

Dental surgeons must have a solid knowledge on cranio-facial anatomy and should know basic aspects regarding the morphology and the location of the GPF, which is necessary for several procedures such as anesthetic techniques, harvesting of palatal soft tissues, dental extractions, dental implant placement, treatment of oroantral communications, among others[4-6].

Because of its importance for clinical dental practice, the location of the GPF must be precisely determined regardless of the number of teeth on the superior alveolar arch, which means that, notwithstanding if the patient is dentulous or edentulous, the practitioner must know how to use the proper landmarks in order to determine the location of the GPF, whereas there are authors who state that several bone structures of the viscerocranium, including the GPF, change its location with the resorption of the alveolar process of the maxilla[7-10].

Despite the existence of publications on the theme, it is necessary to expend current knowledge by adding new variables and by checking the validity of previously studied variables[1,4,7,8,10]. However, the main aspect currently lacking on theme is if there are differences on osteometric parameters of the GPF between dentulous and edentulous individuals. In addition, a study should be performed using a proper sample size by means of sample size calculation, which was not performed on previous studies and is a necessary item for external validity.

Thus, the aim of the present study was to analyze osteometric aspects regarding the location of the greater palatine foramen in dry human skulls with dentulous and edentulous superior alveolar arches.

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Methodology

Ethical Aspects and Sample Size Calculation

In conformity with the Brazilian Federal Law 8.501, November 30, 1992, we used 75 dry human skulls as sample with previous authorization of the institutional Department of Anatomy (Federal University of Pernambuco, Recife, Pernambuco, Brazil), as a part of an umbrella research project approved by the institutional research ethics committee (ID number: 66287517.7.0000.5208).

Sample was obtained by means of sample size calculation, based on the hypothesis of 95% of symmetry between bilateral structures of the hard palate, confidence level of 95% and standard error of 5%.

Eligibility Criteria

Inclusion criteria were: dry human skulls of adult individuals with no distinction of sex, ancestralism and stature, with evidence of eruption of the superior third molars, or with evidence of dental extraction. Exclusion criteria were: evidence of anatomical features that indicate non-adult individuals (deciduous or mixed dentition, opened spheno-occipital synchondrosis, and presence of fonticles), and lack of integrity of bone structures of interest of the hard palate and landmarks of reference.

Variables

The following variables were considered:

1) Anteroposterior diameter of the GPF (APD);

2) Laterolateral diameter of the GPF (LLD);

3) Distance from the GPF to the median palatine suture (GPF-MPS);

4) Distance from the center of the GPF to the most concave point of the posterior margin of the hard palate (GPF-PM);

5) Distance from the posterior margin of the hard palate to the midline between the GPF and the median palatine suture (PM-MP);

6) Distance from the center of the GPF to the posterior margin of the hard palate, immediately posteriorly to the GPF (GPF-PMP);

7) Distance from the center of the GPF to the intersection between the posterior margin of the incisive foramen and the midline (GPF-IF);

8) Distance from the center of the GPF and the craniometric point oralis (GPF-O);

9) Distance from the GPF and the craniometric point staphylius (GPF-STA);

10) Angle between the midline, the craniometric point oralis and the center of the GPF (M-O-GPF).

Figure 1 illustrates and summarizes these measures.

Image Acquisition

Skulls were photographed using the inferior view of the skull base and with a standardized focal distance of 10 centimeters (Figure 2). A rectangular millimeter paper was set at the foramen magnum to obtain the calibration of the software Image J (National Institute of Health, Bethesda, Maryland, USA), which was used for image processing and analyzes.

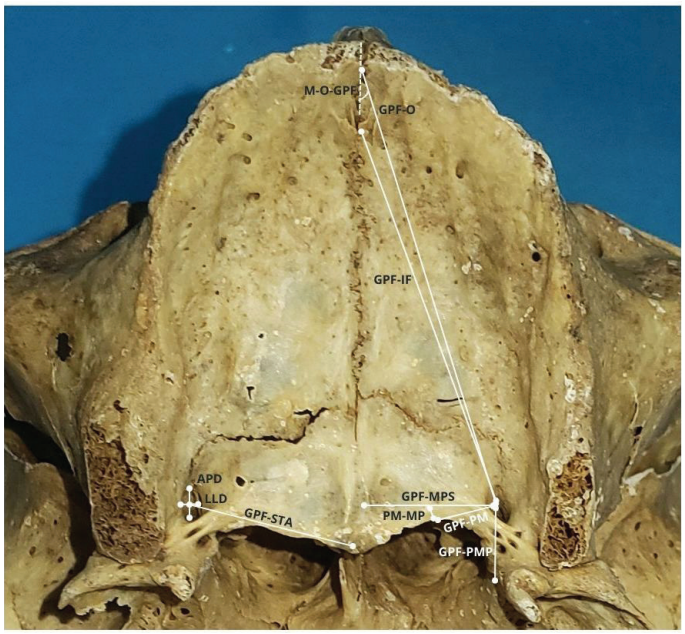

Figure 1. Inferior view of skull base illustrating the measures reported on methodology section.

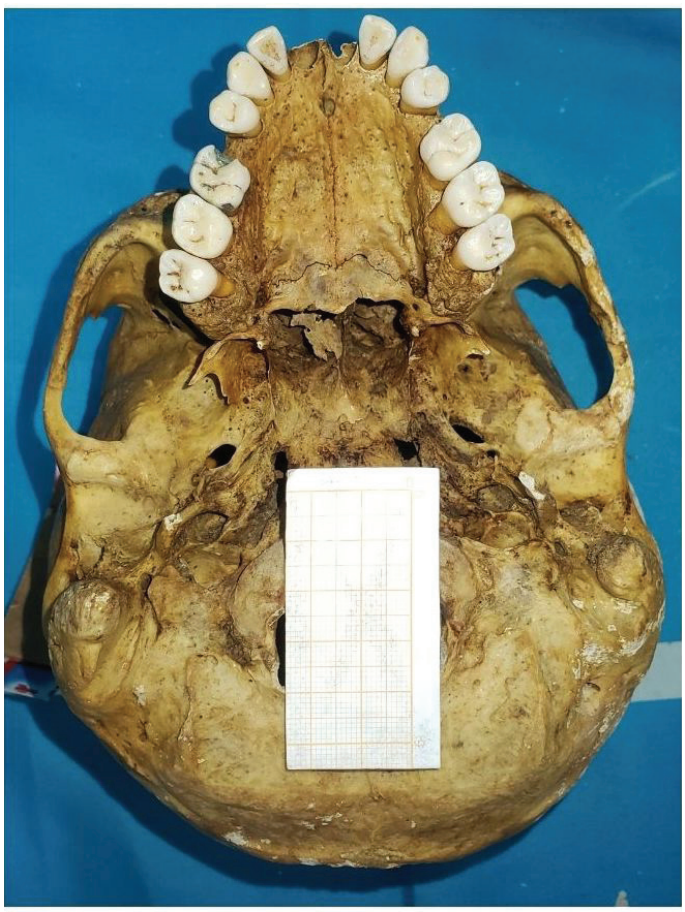

Figure 2. Inferior view of skull base showing an example of image acquisition for posterior processing on Image J.

Statistical Analysis

For bilateral comparisons of continuous variables, the Shapiro-Wilk normality test was used to verify data distribution. Next, the Student's t paired test (for normal data distribution) or the Wilcoxon test (for non-normal distribution of data) was used based on the pairing of right and left sides.

Continuous outcomes were reported as in millimeters as means and standard deviations. The present research established a 95% confidence level and a 5% significance level. All statistical analyzes were performed using the software GraphPad Prism 6.01 (GraphPad, San Diego, California, EUA).

Results

Of the 75 eligible skulls, 23 were dentulous and 52 were edentulous on the superior alveolar arch (i.e. maxillary arch). Analyzes were performed considering different sides (right and left) of skulls with the same dental situation (only dentulous or only edentulous), as well as both situations, simultaneously. In addition, the same side (only right side or only left side) of skulls with different dental situations were also compared (i.e. dentulous vs. edentulous).

Comparison Between the Right and Left Sides

This analysis considered measures of right and left sides obtained on three situations: 1) exclusively from dentulous skulls; 2) exclusively from edentulous skulls; and 3) from both, dentulous and edentulous, altogether.

Five variables (LLD-GPF; GPF-MPS; GPF-PM; FPM-PE; A-LM-PO) presented statistically significant values ($p<0.05$) for the comparison between right and left sides. Data for this analysis are available on Table I.

Comparison between dentulous and edentulous skulls

This analysis considered the comparison of measures between the same sides of skulls with different dental situations (only dentulous or only edentulous).

Three variables (LLD; GPF-O; M-O-GPF) showed statistically significant differences ($p<0.05$). Data for this analysis are available on Table II.

Discussion

The present study analyzed 75 dry human skulls of adult individuals from a Brazilian sample with the same or with different dental situations (i.e. dentulous or edentulous), analyzing possible asymmetries between sides and the influence of the presence of teeth on the GPF anatomy, as well as measures to anatomical landmarks.

Regarding the comparison between right and left sides, five variables (LLD; GPF-MPS; GPF-PM; GPF-STA; M-O-GPF) presented statistically significant

Table 1. Variables considering right (R) and left (L) sides of skulls with the same dental situation (dentulous or edentulous). Values presented as means and standard-deviations. * = indicates a statistically significant p-value; mm = millimeters.

	All			Dentulous			Edentulous		
	R	L	p-value	R	L	p-value	R	L	p-value
APD	1.57 +/-(0.92)	1.65 +/-(0.97)	0.2925	1.58 +/-(0.97)	1.55 +/-(0.90)	0.5464	1.57 +/-(0.90)	1.70 +/-(0.99)	0.1265
LLD	2.20 +/-(0.79)	2.01 +/-(0.72)	0.0123*	1.87 +/-(0.52)	1.84 +/-(0.78)	0.6943	2.34 +/-(0.85)	2.06 +/-(0.69)	0.0033*
GPF-MPS	16.25 +/-(2.12)	16.78 +/-(1.76)	< 0.0001*	16.14 +/-(1.68)	16.60 +/-(1.70)	0.0004*	16.45 +/-(1.79)	16.88 +/-(1.79)	0.0001*
GPF-PM	7.47 +/-(1.98)	7.59 +/-(1.73)	0.0474*	7.42 +/-(2.23)	7.62 +/-(1.71)	0.1882	7.54 +/-(1.86)	7.60 +/-(1.75)	0.2107
PM-MP	2.04 +/-(0.97)	1.88 +/-(0.91)	0.1156	2.06 +/-(0.93)	1.93 +/-(1.04)	0.7904	1.99 +/-(0.97)	1.82 +/-(0.84)	0.0639
GPF-PMP	5.32 +/-(2.27)	5.29 +/-(2.07)	0.8167	5.42 +/-(2.33)	5.32 +/-(2.22)	0.5134	5.28 +/-(2.28)	5.27 +/-(2.04)	0.9778
GPF-IF	42.55 +/-(4.11)	42.69 +/-(4.00)	0.3879	42.42 +/-(3.43)	42.59 +/-(3.29)	0.6837	42.65 +/-(4.40)	42.82 +/-(4.29)	0.3268
GPF-O	52.69 +/-(5.34)	52.75 +/-(5.36)	0.6249	54.61 +/-(4.20)	54.56 +/-(4.15)	0.8579	51.98 +/-(5.63)	52.10 +/-(5.69)	0.6229
GPF-STA	17.54 +/-(1.83)	17.84 +/-(1.89)	0.0011*	17.19 +/-(1.63)	17.39 +/-(2.00)	0.0459*	17.71 +/-(1.91)	18.03 +/-(1.84)	0.0092*
M-O-GPF	18.34 +/-(2.53)	19.28 +/-(2.34)	< 0.0001*	17.08 +/-(2.62)	18.28 +/-(2.41)	0.0055*	18.82 +/-(2.36)	19.69 +/-(2.22)	< 0.0001*

Table 2. Analyzed variables considering the same side of skulls with different dental situations (dentulous or edentulous). Values presented as means and standard-deviations. * = indicates a statistically significant p-value; mm = millimeters; R = right side; L = left side.

	Dentulous	Edentulous	p-value	Dentulous	Edentulous	p-value
	R	R		L	L	
APD	1.58 +/-(0.97)	1.57 +/-(0.90)	0.8305	1.55 +/-(0.90)	1.70 +/-(0.99)	0.3076
LLD	1.87 +/-(0.52)	2.34 +/-(0.85)	0.0008*	1.84 +/-(0.78)	2.06 +/-(0.69)	0.0114*
GPF-MPS	16.14 +/-(1.68)	16.45 +/-(1.79)	0.1704	16.60 +/-(1.70)	16.88 +/-(1.79)	0.3471
GPF-PM	7.42 +/-(2.23)	7.54 +/-(1.86)	0.3219	7.62 +/-(1.71)	7.60 +/-(1.75)	0.6676
PM-MP	2.06 +/-(0.93)	1.99 +/-(0.97)	0.6063	1.99 +/-(0.97)	1.82 +/-(0.84)	0.2242
GPF-PMP	5.42 +/-(2.33)	5.28 +/-(2.28)	0.6645	5.32 +/-(2.22)	5.27 +/-(2.04)	0.9807
GPF-IF	42.42 +/-(3.43)	42.65 +/-(4.40)	0.7690	42.59 +/-(3.29)	42.82 +/-(4.29)	0.9890
GPF-O	54.61 +/-(4.20)	51.98 +/-(5.63)	0.0007*	54.56 +/-(4.15)	52.10 +/-(5.69)	0.0024*
GPF-STA	17.19 +/-(1.63)	17.71 +/-(1.91)	0.1853	17.39 +/-(2.00)	18.03 +/-(1.84)	0.1058
M-O-GPF	17.08 +/-(2.62)	18.82 +/-(2.36)	< 0.0001*	18.28 +/-(2.41)	19.69 +/-(2.22)	0.0003*

values ($p<0.05$). One can see on Table I that the small differences may not be important from a clinical perspective. This shows that, in despite of a small anatomical asymmetry for the aforementioned variables, they could be considered as symmetric for possible clinical purposes. In addition, it could be considered that the presence or absence or teeth had no interference on these variables.

Regarding the analysis between dentulous and edentulous skulls, three variables (LLD; GPF-O; M-O-GPF) showed statistically significant differences ($p<0.05$). Considering that the anteroposterior diameter of the GPF (APD) did not present statistically significant differences and that the laterolateral diameter of the GPF (LLD) presented statistically significant differences, bilaterally, this confirms that the GPF has an oval morphology (i.e. shape), which was showed on previous studies that did not compared dentulous and edentulous maxillary arches. However, the present study showed that edentulous skulls presented GPF larger laterolaterally than dentulous skulls, and, thus, closer to the residual alveolar crest nearby. This is especially relevant for the greater palatine nerve block and for harvesting connective tissue grafts on the region of the tuber of maxilla[2,5,9].

The distance between the craniometric point oralis and the GPF (GPF-O) was also statistically significant. This anatomical landmark is relevant and useful on edentulous patients for the greater palatine nerve block, since these patients have no dental landmarks. The values presented indicate that the GPF can be found closer the craniometric point oralis on edentulous individuals than on dentulous ones, which also means that the needle will find its target more briefly. Moreover, indirectly, one may also understand that there is an antero-posterior shortening of the hard palate, which may represent and narrower antero-posterior length of the hard palate, thus representing a smaller useful region for harvesting connective tissue from this region. Nevertheless, this hypothesis needs to be confirmed on future research.

Another statistical difference occurred on the angle between the GPF, the craniometric point oralis and the midline (M-O-GPF). However, in despite of mathematical differences, the small differences identified (around one degree), may not be clinically relevant, considering a one degree angle of the needle in any axis of rotation is difficult (if not impossible) to control manually, and will probably not represent failure on anesthetic technique.

Conclusions

The right and left sides could be considered symmetric;

Edentulous skulls presented larger GPF on the laterolateral axis than dentulous skulls;

GPFs were closer to the craniometric point oralis on edentulous skulls.

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