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Original Article

Artigo Original

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Study of the correlation between the linear measurements of the skull and face and palatal wide and length measures

Estudo da correlação entre as medidas lineares de crânio e face e as medidas de largura e comprimento palatino

Keywords

Anthropometry
Skull
Hard palate
Face
Speech–language pathology and audiology

ABSTRACT

Objective: To analyze the relation between the anthropometric linear measurements of the skull and face and the measurements of width and length of the hard palate. **Methods:** Twenty-three human skulls were used, and the measurements were collected with the help of a caliper and pelvimeter. The following linear measurements were studied: maximum cranial length, biporion distance, maximum face width, nasal height, palatal length, and palatal width. **Results:** After a complete descriptive assessment of the variables, we observed homogeneity in the measurements of the skull, face, and palate. There were correlations, with higher significance, between the palatal length and width and the maximum face width and the biporion distance, respectively. The biporion distance was the only measurement that was significant in the explanation, generating formulas to obtain the palatal length and width. **Conclusion:** It is possible to estimate the palatal length and the palatal width using the two models (formulas) through the measurements of the biporion distance. Because in the literature, there is no consensus, there is a need for standardization when obtaining the linear measurements of the palate.

Descritores

Descritores
Antropometria
Crânio
Palato duro
Face
Fonoaudiologia

RESUMO

Objetivo: Analisar a relação entre as medidas lineares antropométricas de crânio e face com as medidas de largura e comprimento do palato duro. **M**étodos: foram utilizados 23 crânios humanos e as medidas foram obtidas com o auxílio de um paquímetro e um pelvímetro. Foram mensuradas as seguintes medidas lineares: comprimento máximo do crânio, distância biporion, largura facial máxima, altura nasal, comprimento palatino e largura palatina. **Resultados:** Após a descritiva completa das variáveis, observou-se uma homogeneidade das medidas de crânio, face e palato. Houve correlação, com maior significância, do comprimento palatino e da largura palatina com a largura facial máxima e a distância biporion, respectivamente. A distância biporion foi a única medida que se mostrou significante na explicação, gerando fórmulas para a obtenção do comprimento e de largura palatina. **Conclusão:** É possível estimar o comprimento e a largura palatina por meio de dois modelos (fórmulas) por meio da medida da distância biporion. Como não existe consenso na literatura, há necessidade de padronização na obtenção das medidas lineares do palato.

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INTRODUCTION

The hard palate plays an important role in the functions of the stomatognathic system. This system consists of a heterogeneous set of organs and tissues, which exhibit functions related to mastication, deglutition, phonation, expression, and facial aesthetics, while maintaining the posture of the jaw, the tongue, and the hyoid bone[1].

Morphological alterations in the structure of the stomatognathic system entail adaptations in deglutition, mastication, speech articulation, and breathing. This means that, in the evaluation of the hard palate, if the morphology is altered, the functions that need this structure will also likely be altered or at least adapted[2].

Despite the importance of anthropometry in speech-language pathology and audiology, particularly, in the area of orofacial motricity, the morphology and morphometry of the hard palate have not been studied very intensively by professionals in this area[2].

There is no consensus in the literature regarding the nomenclature in the subjective evaluation of the hard palate within the practice of speech-language pathology and audiology. Various terms are used to describe the hard palate in the diagnosis of this structure, such as regular, high-arched, high, low, deep or atresic; narrow, wide, and sloping; and of ovoid shape, trapezoid, and triangular[2]. Thus, it can be observed that the hard palate is difficult to assess clinically, and part of that difficulty is owing to the lack of objective measurements[3].

The objective of this study is to analyze the correlation between the measurements of the hard palate and the anthropometric measurements of the skull and face in anatomical parts.

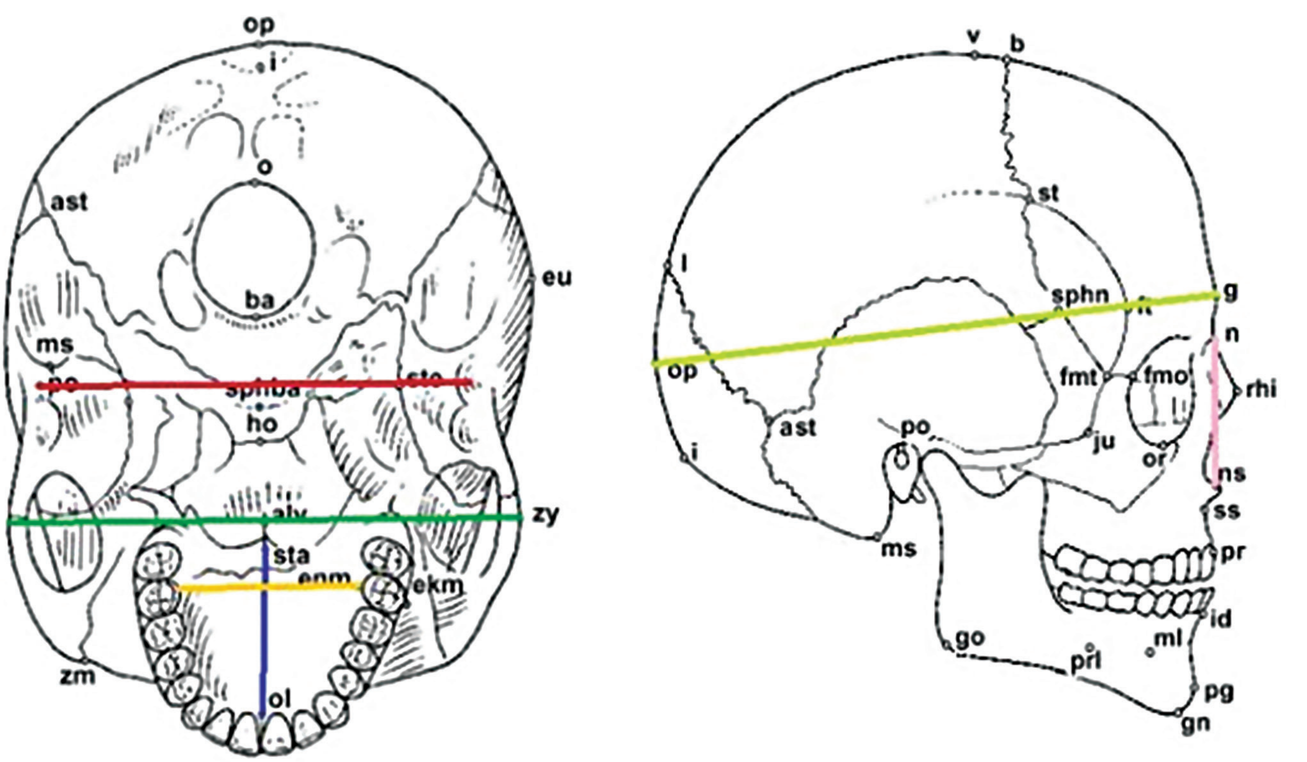
METHODS

In this cross-sectional study, 23 adult skulls were analyzed. Skulls that presented nonvisible or damaged bone surfaces, which prevented the measuring, were excluded from this research.

The skull, face, and hard palate measurements were obtained with the aid of a digital caliper of the Mitutoyo CD-6”CSX-B® brand and a pelvimeter from Casa Lhoner.

The measurements obtained were: the maximum skull length (opisthocranion to glabela, G–Op), biporion distance (right porion to left porion, Bi–Po), nasal height (nasion to nasospinale, N–Ns), maximum face width (right zygion to left zygion, Bi–Zi), palatal length (staphylion to orale, Ol – Sta), and palatal width (right endomolare to left endomolare, Bi – Enm). Each measurement, in each skull, was obtained only once. For this, the craniometric points shown in Figure 1 were used[4].

After obtaining the measurements, the correlation between the width and length of the palate was assessed in relation to the biporion distance, maximum facial width, nasal height, and maximum skull length.



Caption = ast: asterion; ms: mastoideale; op: opistokranion; o: opisthion; ba: basion; eu: eurion; po: porion; sphba: sphenobasion ho:hormion; ste: stenion; sta: staphylion; alv: alveolon; enm: endomolare; ekm: ektomalare; zy: zygion; ol: orale; zm: zygomaxillare; gn: gnathion; pg: pogonion; prl:prominentia laterale; ml: mentale; id: infradentale; go: gonion; pr: prosthion; ss: subspinale; ns: nasospinale; rhi: rhinion; n: nasion; g: glabela; sphn: sphenion; fmt: frontomalare temporale; ju: jugale; or: orbitale; v: vertex; b: bregma; st: sthepanion; l: lambda. Modified from: Pereira and Alvim (1979).

Maximum skull length (opisthocranion to glabela G-Op); biporion distance (right porion to left porion Bi-Po); nasal height (nasion to nasospinale N-Ns); maximum face width (right zygion to left zygion Bi-Zi); palatal length (staphylion to orale Ol-Sta); palatal width (right endomolare to left endomolare Bi-Enm).

Figure 1. Linear Measurements used according to craniometric points

For the statistical analysis, the following software was used: SPSS V17® for the correlation analyses and Minitab 16® for the reliability analysis.

A complete descriptive analysis was performed for each measure (mean, median, standard deviation, coefficient of variance, minimum, maximum, and confidence interval). The correlations between the length or width of the palate and the other measurements of each skull were tested using Spearman's correlation coefficient[5], to verify if there was a significant correlation. The multiple linear regression test was applied in order to make an estimate of the width and length of the palate through other measurements known as "independent," as, for example, the width of the face. In the data analysis, the significance level was 0.05 (5%).

RESULTS

Among the 23 selected skulls, it was possible to obtain the length (Ol–Sta) and width (Bi–Enm) of the hard palate in 12, considering the skulls presented all measurable bone surfaces intact. In 7 skulls, it was not possible to measure the palatal width (Bi–Enm), and, in 4 skulls, the palatal length (Ol – Sta), because the pieces were damaged in places where the three craniometric points would be obtained.

Table 1 shows the complete descriptive analysis for all the quantitative variables. According to the coefficient of variance (CV), and the presented data, it can be noted that the measurements are homogeneous (less than 50%), as, for example, in the mean of the palatal width (Bi–Enm). According to the confidence interval (CI), the mean was 33.5±1.5 mm.

The Spearman's correlation test was used to measure how much the length and the width are related to the other measures. According to Table 2, there was a statistically significant correlation, such as the one observed between the palatal width (Bi–Enm) and the biporion distance (Bi–Po), with a value of 59.1%. The other measurements, although with no statistically significant correlation, revealed significant similarities.

The results were also submitted to the multiple linear regression method. As shown in Tables 3 and 4, it can be noted that for both the models of palatal width (Bi–Enm) and palatal length (Ol–Sta), only the biporion distance (Bi–Po) is significant in the estimate of the two measurements.

Therefore, according to the percentage of the coefficient of multiple determination (R^2), which represents the quality (estimated capacity) of each formula, both the final models were

Table 2. Correlation between palatal length and width with the linear cranial and facial measurements

		G–Op	Bi–Po	Bi–Zi	N–Ns
Palatal length	Correlation (r)	39.0%	34.9%	43.5%	6.5%
(Ol–Sta)	p-value	0.099	0.143	0.063	0.792
Palatal width	Correlation (r)	19.8%	59.1%	45.6%	-2.4%
(Bi–Enm)	p-value	0.462	0.016	0.076	0.931

Caption: G–Op = maximum skull length; Bi–Po: biporion distance; Bi–Zi = maximum face width; N–Ns = nasal height. Source = Primary data (2014).

Table 3. Regression Model for palatal width (Bi–Enm)

Bi–Enm	Initial		Final	
	Coefficient	P-value	Coefficient	P-value
Constant	-6.796	0.869	-10.281	0.490
G–Op	-0.148	0.589		
Bi–Po	0.487	0.164	0.380	0.013
Bi–Zi	0.167	0.701		
N–Ns	0.064	0.866		
Ol–Sta	-0.268	0.407		
R^2	60.7%		47.9%	
ANOVA	0.238		0.013	

Caption: G–Op = maximum skull length, Bi–Po = biporion distance; Bi–Zi = maximum face width; N–Ns = nasal height; Bi–Enm = palatal width; Ol–Sta = palatal length; R^2 = coefficient of multiple determination, ANOVA: = analysis of variance.

Table 4. Regression Model for palatal length (Ol–Sta)

Ol–Sta	Initial		Final	
	Coefficient	p-value	Coefficient	p-value
Constant	-40.292	0.431	-6.086	0.739
G – Op	0.114	0.746		
Bi – Po	0.321	0.499	0.414	0.023
Bi – Zi	0.414	0.447		
N – Ns	-0.146	0.763		
Bi – Enm	-0.435	0.407		
R^2	53.4%		41.7%	
ANOVA	0.351		0.023	

Caption: G–Op = maximum skull length; Bi–Po = biporion distance; Bi–Zi = maximum face width; N–Ns = nasal height; Bi–Enm = palatal width; Ol–Sta = palatal length. R^2 = coefficient of multiple determination; ANOVA = analysis of variance.

Table 1 . Complete description of variables

Description	G–Op	Bi–Po	Bi–Zi	N–Ns	Ol–Sta	Bi–Enm
Mean	177.2	114.4	111.7	50.3	41	33.5
Median	175	114.6	112.2	50.6	40.2	34.4
Standard Deviation	6.4	5.7	5.4	4.2	3.7	3
Coefficient of variance	4%	5%	5%	8%	9%	9%
Minimum	165	101.5	97.2	42.6	34.7	28.1
Maximum	190	124	119.8	58.7	47	37.6
n	23	23	23	23	19	16
Confidence Interval	2.6	2.3	2.2	1.7	1.7	1.5

Caption: G–Op = maximum skull length, Bi–Po: biporion distance, Bi–Zi: maximum face width, N–Ns: nasal height, Bi–Enm: palatal width, Ol–Sta: palatal length.

significant, because we have a R^2 of 47.9% and 41.7% for Bi–Enm and Ol–Sta, respectively. This enabled the development of two final models or formulas:

$$Bi\text{–}Enm = -10.281 + 0.380 * Bi\text{–}Po \quad (1)$$

$$OI\text{–}Sta = -6.0861 + 0.414 * Bi\text{–}Po \quad (2)$$

Using these formulas, if the biporion distance measurement (Bi–Po) of a certain individual was placed within each model set out in the above-mentioned formulas, there would be a 47.9% chance of finding the approximate measurement of palatal width (Bi–Enm) and a 41.7% chance of finding the measurement of palatal length (Ol–Sta).

DISCUSSION

The descriptive analysis of all the observed measurements, shown in Table 2, is important so that we can, when possible, check for a normal standard of measurements or even to compare them in populations with different ethnic groups, in a process similar to that carried out in other researches[6-10]. Moreover, it is also possible to evaluate the anthropometric characteristics of certain anthropometric structures inside a population, age group, and/or gender. In this study, we observed a tendency to a standard of measures, from the average of the palate, face, and skull.

When compared with the results obtained in the descriptive analysis of this study, a similar study[11] showed higher mean values for the length and palatal width: 51 mm for females and 52.9 mm for male subjects, regarding the palatal length. As for the palatal width, the number obtained was 37.4 mm in female and 38.5 mm in male subjects.

However, the other measurements of skull and face found in this study showed similar values to those of the mentioned authors. One possible explanation for the similarity of the results of these measurements is that the mentioned study[11] was carried out with subjects of Portuguese nationality; therefore, the sample of this study is compatible with the individuals of supposedly similar lineage. The standard deviation values verified by the authors were above the results obtained in this study, probably because, their sample was higher (400 skulls), and skulls that showed contradictory measures were not excluded from the sample. Thus, the high value of the standard deviation for each measurement may have caused the low level of correlation between the skull and face measurements and the palatal measurements found in the mentioned study. In this study, all the 23 measured skulls were used, because there was no discrepancy between the obtained measurements.

The homogeneity of measurements obtained in this study allowed us to verify a correlation and able to generate a model that enables the estimate of the length and width of the palate through a measurement of the skull. However, it is not possible to state that these measurements reflect the classification of facial typology. Other authors[11] also observed homogeneous measures; although they have been able to establish a correlation, they concluded that there was no difference between the samples, attributing the results to the fact that they had studied mostly brachycephalic individuals.

The measurements of length, width, and depth of the hard palate were made by researchers[12] in plaster models, in order to compare with the oral and nasal breathing children. The authors also found homogeneous measures of length in different facial types. However, when we considered the oral or nasal breathing in children, the measurements of palatal width were not homogeneous regarding these two parameters. These data corroborate with what the literature in the field of orofacial motricity reports, namely, that mouth breathers showed a narrower and deep palate[13]. Although this was not the goal of this study, the work of the mentioned authors[12] shows the importance of obtaining the hard palate measurements for the speech–language pathology and audiology.

In this same mentioned research[12], the authors showed mean palatal width higher than the one observed in this study, with a mean of 36.52 mm in brachyfacial individuals, 35.75 mm in mesofacial individuals, and 35.09 mm in dolichofacial individuals. One possible explanation is that the authors measured the palatal width, obtaining the distance between the first molars and not the palate directly, which probably would present a smaller measurement. But, the anteroposterior length measurements of the palate obtained by the authors were lower when compared with the results of this study, which is consistent with the morphological differences of structure between the two age groups. The brachyfacials individuals showed a mean of 35.09 mm, the mesofacial individuals, of 34.48 mm, and the dolichofacial individuals, of 34.76 mm.

The depth of the palate, despite having not been measured in this study, is an important measurement to be considered in future studies on the subject. A skeletal alteration that increases the depth of the hard palate can interfere with the breathing pattern of an individual, as it was verified by the same study mentioned above[12], in which the authors compared the difference in measurements between nasal and mouth breathers. The authors obtained the measurement of the depth using stainless steel wires and the caliper's stick.

The choice of the points in the region of the second molars was used[2] for obtaining the palatal width and length for adults in plaster models, using a caliper. The mean of the measurements of palatal length of this study was 41 mm, which, when compared with the measurements obtained by Costa et al.[2], was lower. This divergent result can be justified by the way the measurements were obtained, because the authors used, as a posterior limit, a caliper adapted for obtaining this measure, the line passing at the level of the mesial faces of second molars and, as an anterior limit, the lower limit of the space of the superior central incisors. The two authors first classified the palate as normal or high arched, and then the mean, in accordance with this classification, was obtained.

According to the classification of the first author, the palatal length measurements, defined as normal, registered an average of 44.28 mm, and the high-arched ones, of 45.98 mm. In the evaluation of the second author, the palates considered normal, obtained a mean length of 45.9 mm, and the high-arched ones, of 44.69 mm.

Regarding the palatal width, the mean verified in this study was 33.5 mm, less than the one verified by the authors mentioned earlier[2]. This is, probably, because, the authors measured the distance between the second molars and not just the hard palate's distance. According to the classification of the first author, the palatal width measurements, defined as normal, showed a mean of 41.47 mm, and the high-arched ones, of 40.38 mm. In the evaluation of the second author, the width measurements of the palates considered normal showed a mean of 41.51 mm, and the high-arched ones, of 40.47 mm. Whereas the tooth is not part of the palate and can also affect the measuring, depending on the patient's occlusion, it is likely that the measurements obtained by the authors may be less authentic than those performed in this study, which used the points *orale* (Ol) and *sthapylion* (St) to obtain the length, and the point endomolare bilaterally (Enm), to obtain the width.

In another study[14], the researchers also correlated the quantitative and qualitative methods for the classification of the hard palate of children through measuring and evaluation of three judges. According to the palatal height index, the authors classified the hard palate in high, medium, and low and concluded that, in the qualitative analysis, there was a tendency to consider in some cases the palate as high, differently from what the measurement of depth using the quantitative method indicated.

In another research[15], the authors carried out a study that also evaluated the length, width, and depth of the palate in adults. However, they used other anthropometric points, considering the mesiobuccal cusp of the superior first molars to obtain the palatal width, and they included the size of the teeth in the measurement. Thus, the values of this measurement were considerably higher than the ones found in this study, obtaining the mean of 50.95 mm for brachyfacial individuals, 51.10 mm for mesofacial individuals, and 50.24 mm for dolichofacial individuals. Regarding the length, the values of the measurements were lower because the authors also used as posterior tangent (posterior limit) the mesio-vestibular cusp of the upper first molars, obtaining a mean of 30.67 mm for brachyfacial individuals, 30.17 mm for mesofacial individuals, and 30.54 mm for dolichofacial individuals.

The result of the significant correlation between Bi–Po and Bi–Enm is interesting because the point porion (Po) is located in the superior and external edge of the external acoustic meatus, and this is a point that does not suffer so many morphological alterations during the life of the individual, only during the craniofacial growth, in the case of a temporal bone fracture or some surgical procedure. Thus, the biporion measurement is probably reliable for a possible prediction or correlation of the palatal width.

The correlations obtained in this study, because they are positive, indicate that, the higher the value of Bi–Po and Bi–Zi, the higher the value of Bi–Enm and Ol–Sta, respectively.

In a similar study[11], the authors did not find any significant correlation values when they correlated the palatal width and length with other craniofacial measurements, because they analyzed mostly brachycephalic individuals. The multiple linear regression method was performed in the same mentioned study[11], but the authors did not obtain a significant correlation to make it possible to generate a model that was able of estimating the palatal length and width through other craniofacial measurements. As mentioned earlier, the cause may have been the high value of standard deviation found in the sample containing 400 skulls, which could have been avoided excluding the skulls that had very deviant values (nonstandard) from the sample.

Some studies[12,14,15] carried out quantitative analysis of the depth of the hard palate. It would be interesting to apply a multiple linear regression test in the search for prediction of this variable from other measurements, because it is an important anatomical feature within the speech–language pathology and audiology assessment. Depending on the test result, and if it is possible to have a prediction formula for this feature, it would contribute to a more specific assessment.

Other studies[16,17] found that mouth breathers exhibit altered hard palate, usually narrower (palatal width with lower values) and in greater depth, because the altered breathing pattern results in a skeletal change. Thus, obtaining a model (formula) with the use of skull or face measurements that would allow estimating the palatal width would be an easier and less expensive way of correlating the palatal width with the breathing pattern of the assessed individual.

This type of quantitative analysis proves important in various ways, such as when there is a lack of consensus in the clinical assessment of the hard palate, especially, in cases in which the structure does not show a large skeleton alteration. For certain studies[2], there was a disagreement between the qualitative assessments of the two speech–language pathologists specialized in orofacial motricity. This type of research also helps in the classification and standardization of normality and alteration in the structure, because the authors observed, for the palates considered normal, a mean palatal depth of 14.4 mm, and for high-arched palates, a mean of 17.3 mm. In this study, despite obtaining a mean for the analyzed structures, it was not possible to determine a normal or alteration pattern, because the qualitative analysis of structures was not carried out.

CONCLUSION

The full descriptive analysis of the variables indicated that the sample of measurements of skull, face, and palate are homogeneous; as for the biporion distance (Bi–Po), it was the linear measurement that showed higher correlation with the palatal width (Bi–Enm). There seems to be a correlation between the maximum face width (Bi–Zi) and the palatal length (Ol–Sta); so, it was possible to obtain significant models (formulas) able to calculate the palatal width (Bi–Enm) and length (Ol–Sta), using the biporion distance measurement (Bi–Po) of the assessed individual.

The lack of consensus in the literature about obtaining the measurements of the palatal width means that the measurements used in this study can be adopted for future studies about the theme, because, through them, it is possible to obtain more accurate measurements of the palate. In addition, we suggest that more studies are conducted with a higher number of skulls.

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