

# A morphometrical study of the human palatine sutures

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*The paper presents metrical data on the palatine sutures of a dry skull collection comprising 29 male and 33 female specimens. The length and mutual proportions of the mid-palatal, interpalatine and transverse palatine sutures were considered. These properties led to a conclusion as to the extent to which the palatine process of the maxilla and palatine bones dominate in the formation of the hard palate. We discovered that the palatine process of the maxilla is prevalent and that it constitutes approximately 65% of the hard palate in both sexes. Moreover our findings indicated a significant correlation in the diameters of the palatine sutures that are arranged sagittally.*

**key words:** palatine sutures, cranial sutures, hard palate

## INTRODUCTION

A knowledge of the structure of palatine sutures and the anatomical relations between them is important for a better understanding of the etio-pathogenesis of malformations of this cranial region. The hard palate and its sutures are structures of the utmost importance because they are subject to a cleft palate related defect of the maxilla and palatine bones.

The hard palate consists of two palatal processes of the maxilla and two horizontal plates of the palatine bones that are connected by the palatine sutures. The sutural system of the hard palate basically comprises premaxillary, mid-palatal, palatomaxillary, and interpalatal articulations. The premaxillary suture exists between the premaxillary bones and the maxilla [4, 12]. The mid-palatal suture extends from the incisive canal to the transverse palatine (palatomaxillary) suture posteriorly, which joins the horizontal plates of the palatal bones and the palatal processes of the maxilla. The two horizontal plates of palatine bones are joined

by the interpalatal suture [5]. The median and transverse palatine sutures mark the lines of connection between the bones of the palate and so their length corresponds to the diameter of the respective bones, which are joined by these sutures. Thus metrical features of the palatine suture become a counterpart of the diameters of the bones which form the hard palate and make it possible to deduce to what extent both horizontal plates of the palatine bone and palatine processes of the maxilla are engaged in the formation of the hard palate.

The goal of this paper is to present the metrical variation in the length of the palatine sutures and to establish the correlation, if any, between them. We focused only on analysis of the mid-palatal, transverse palatine suture and the interpalatine sutures, as these occur in adults and were observed in the skulls investigated. Hence we tried to estimate to what extent the palatine bones and the horizontal plates of the maxilla contribute to the formation of the hard palate.

## MATERIAL AND METHODS

The palatine sutures were investigated of 29 male and 33 female adult skulls belonging to the Anthropological Museum of the Jagiellonian University. The skulls are dated to a period between the XV and XVIII century and were excavated in Kraków.

The lengths of the palatine sutures was measured with a spreading calliper following anthropological principles [7, 8]. The following measurements were applied (Fig. 1):

- *alv-sr* — length of the interpalatine suture;
- *sr-inc* — length of the mid-palatal suture;
- *alv-inc* — length of sagittal sutural system of the hard palate, regarded as the sum of the lengths of the mid-palatal and interpalatine suture;
- *spal-spal* — length of the transverse palatal suture.

Additionally, a new measurement was introduced. This concerned the length of the chord between the *staurion* (*sr*) and the landmark that is fixed in a place of direct contact between the mid-palatal suture and the posterior margin of the incisive foramen. This landmark was assigned for measurements with the *inc* symbol and was termed *incisulare*. The chord *sr-inc* expresses the length of the mid-palatal suture of the hard palate that originates from the same palatine shelves.

The percentage of palatine bones and maxilla in the formation of the hard palate was calculated as the following ratios:  $(alv-sr)/(alv-inc) \times 100$  and  $(sr-inc)/(alv-inc) \times 100$ . Statistical analyses were performed on a file of collected data. As a first step we rejected outliers, those values, which were far from the middle of the distribution. Such values were detected using a box-whisker plot that describes the central tendency of the variable in terms of the median of the values (represented by the smallest box

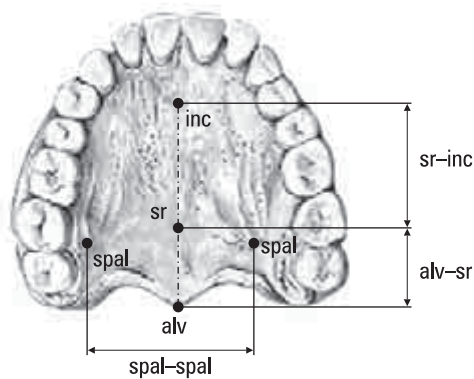


Figure 1. Measurements of the palatine sutures.

in the plot). The spread (variability) in the values is represented in this plot by the quartiles (the 25<sup>th</sup> and 75<sup>th</sup> percentiles, the larger box in the plot) and the minimum and maximum values of the variable (the „whiskers” in the plot). The correlation matrix of all the variables was then run and examined for significant relations. The significance level calculated for each correlation was equal 0.05 and Pearson’s correlation coefficients were used to assess the associations between analysed variables. A comparison was also performed of the means of all the variables attributed to male and female skulls to determine whether there were any differences between the sexes in length of palatine sutures.

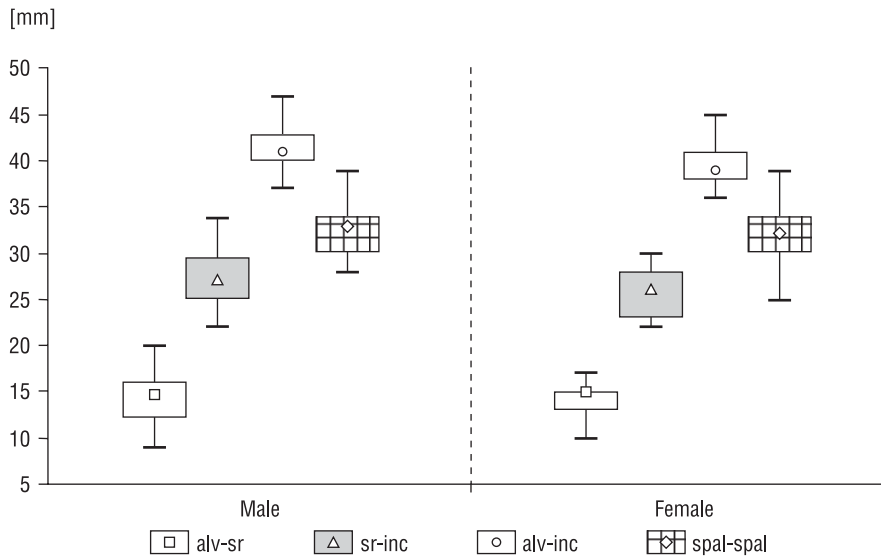
## RESULTS

The box-whisker plot shows the statistical character of the metrical data studied for the palatine sutures (Fig. 2). The mean values of the metrical features investigated for the bony palate of the male and female skulls and the range of their variability is presented in Table 1. The correlation between the metrical features studied for the bony palate and their sutures is demonstrated in Table 2 and 3. Table 4 presents the percentage of the interpalatine suture and the mid-palatine suture in the whole sagittal suture system of the hard palate in both sexes.

The comparison of means of the palatine suture length indicated a lack of statistically significant differences ( $p > 0.05$ ) between the male and female groups. The length of the subsequent palatine sutures was almost equal in both sexes. In the sagittal suture system of the hard palate the mid-palatal suture (*sr-inc*) was nearly twice as long as the interpalatine suture (*alv-sr*).

The percentage of the interpalatine suture (*alv-sr*) and the mid-palatal suture (*sr-inc*) in the whole sagittal system of palatine sutures (*alv-inc*) is also similar in male and females skulls. The mid-palatal suture dominates in both sexes and thus indicates that palatal processes of the maxilla constitute about 65% of the bony palate, whereas the horizontal plates of the palatine bone constitute about 35%.

In the male skulls studied an increase in the interpalatine suture length results in a decrease in the mid-palatal suture length and this relation is statistically significant. Such a rule was not observed in the female skulls. There is also a difference in both sexes concerning the significance of the correlation between the lengths of the interpalatine suture and mid-palatal suture on the one hand and



**Figure 2.** Box-whisker plot for variables, which represent the length of the palatine sutures after rejection outliers.

**Table 1.** Means and range of variation of the length of the palatine suture

Suture segment	Sample		Mean		Minimum		Maximum		SD	
	M	F	M	F	M	F	M	F	M	F
alv-sr	28	29	14.3	14.1	9.0	10.0	20.0	17.0	2.393	2.110
sr-inc	28	29	27.3	25.8	22.0	22.0	34.0	30.0	3.193	2.555
alv-inc	28	29	41.5	39.8	37.0	36.0	47.0	45.0	2.560	2.610
spal-spal	28	29	32.5	32.1	28.0	25.0	39.0	39.0	2.848	2.615

M — male, F — female

**Table 2.** Correlation matrix of diameters of the bony palate in female skulls

Feature	alv-sr	sr-inc	alv-inc	spal-spal
alv-sr	1.00	-0.27	0.49*	0.24
sr-inc	-0.27	1.00	0.70*	0.18
alv-inc	0.49*	0.70*	1.00	0.35
spal-spal	0.24	0.18	0.35	1.00

\* Denotes statistically significant correlation,  $p < 0.05$

**Table 3.** Correlation matrix of diameters of the bony palate in male skulls

Feature	alv-sr	sr-inc	alv-inc	spal-spal
alv-sr	1.00	-0.63*	0.35	-0.07
sr-inc	-0.63*	1.00	0.50*	0.28
alv-inc	0.35	0.50*	1.00	0.23
spal-spal	-0.07	0.28	0.23	1.00

\* Denotes statistically significant correlation,  $p < 0.05$

**Table 4.** Percentage of the palatine suture segment in the male and female skulls

Suture segment	Sample		Mean		Minimum		Maximum	
	M	F	M	F	M	F	M	F
$(alv-sr)/(alv-inc) \times 100$	28	29	34.3	35.3	20.9	25.6	46.3	42.5
$(sr-inc)/(alv-inc) \times 100$	28	29	65.7	64.7	53.7	57.5	79.1	74.4

M — male, F — female

the length of the whole sagittal sutural system of the hard palate on the other. The length of the whole sagittal sutural system of the hard palates analysed correlates significantly with the length of the mid-palatal suture in the male skulls, while in the female skulls it correlates significantly both with the length of the interpalatine suture and the length of the mid-palatal suture. In neither sex was there any significant correlation between the length of the transverse palatine suture and other palatine sutures in the cranial set under examination.

On the basis of these considerations it may be concluded that the size of the palatal bones, demarcated by the length of the interpalatine suture, has a significant effect on the longitudinal dimensions of the bony palate, both in the female and male skull.

## DISCUSSION

The human osseous palate consists of the palatine processes of the maxillary bone anterior to the transverse palatine suture and the horizontal processes of the palatine bone posterior to that suture. These bones are joined by the sutures arranged into two systems, the sagittal and the transverse, running at right angles to each other and this enables two-directional growth of the palate (antero-posterior elongation and lateral widening). The increase in total length results predominantly from an increase in the antero-posterior dimension of the maxillary component [10] and this is possible owing to the presence of the transverse palatine suture (palatato-maxillary), which serves as a site of growth [6]. The mid-palatal and interpalatine sutures belong to the sagittal suture system, and permit growth into width of the facial skeleton, while the transverse palatine suture (palatato-maxillary) facilitates longitudinal growth of the maxilla [11].

The metrical comparison between the length of the palatine sutures of the male and female skulls revealed that they are of similar proportions. However, there are differences between the sexes in the correlation between the lengths of the subsequent sutures of the hard palate. This can be a result of a different pattern of growth that occurs in the hard palate of the male and female skulls. The results obtained allow us to conclude that in the female skulls both the palatine processes of the maxilla and the horizontal laminae of the palatine bones may independently influence the length of the bony palate. An increase in the participation of the palatine bones in palate formation results in a decrease in

the size of the maxilla and this is characteristic of the male skulls studied.

No statistically significant correlation was detected between the length of the transverse palatine suture and the interpalatine suture or the mid-palatal suture in the cranial set studied. The lack of correlation between the lengths of these sutures probably suggests that the palatine sutures, as the sites of growth, increase independently of diameters of the bony palate. Thus the interpalatine and mid-palatal sutures allow the transverse growth of the palate, while the transverse palatine suture provides longitudinal growth of the palate, as it remains in accordance with embryological evidence [1, 12].

The morphological relations of the palatine bones to the maxilla are important in any consideration of multidirectional enlargement of the hard palate in accordance with the growth of the whole skull [3]. Morphometrical analysis of the palatal sutures supplies information about anatomical dependences resulting from the principles of craniofacial development. It would seem important to evaluate to what extent diameters of the bony palate increase with an increase in the sutural length. Palatine sutures could be regarded as a keystone in the proper co-ordination of the growth of the whole skull. As Persson stated, palatine suture formation is a response to the displacement of the bones involved in the growth process during enlargement of the skull [9]. Results of the primary observations and metrical analysis of the palatine sutures may lead to a new concept of anatomical research into co-ordinated craniofacial growth that can be controlled by different factors such as age or ethnicity [2].

It should be emphasised that our analysis was performed on a relatively small sample, which prevents definitive conclusions from being drawn, which would have to be supported by results obtained from numerous sets of human skulls. Detailed studies of metrical relations among the palatal sutures should also be concerned with age changes. However, such longitudinal studies are hard to perform because of the limitations imposed by the lack of numerous male and female cranial series composed of different age groups.

Our study suggests that palatine sutures appear to be important structures, which are engaged in craniofacial growth. Together with other maxillary sutures they allow the maxilla to displace in an antero-posterior direction relative to the adjacent suture margins of the palatine bones. The morphometrical relations between palatine sutures reflect the mode

of interaction between the palatine bones and maxilla during their growth.

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