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Hard Palatal Anthropometry and its Significance in Orthodontics

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Hard palatal dimensions and indices, and skull and head dimensions are estimated on bone material and living individuals in groups of different age through classic anthropometric methods. The correlation observed and its significance for prophylaxis, diagnosis and treatment of some dento-occlusal abnormalities are analyzed.

Key words: anthropometry, hard palate, skull, head, correlations.

Human hard palate disposition, structure, and variable functional characteristics play an important role in the upper segments of the digestive and respiratory systems. The development and growth of hard palate are influenced, on the one hand, by the whole-body growth factors, and these of the head, in particular, and, on the other, by the development of teeth follicles and the teeth themselves. The latter correlation is clearly observed in hard palatal morphometric characteristics analysis of different aged groups, as shown in the studies of M. H e l l m a n [1], J. J o r d a n o v [8, 9, 11, 12], V. K r u m o v a [14] et al. Palatal and head dimensions ratio expresses the whole-body growth factors. Some researchers only describe the existence and role of this relationship and other define its quantitative expression. In a genetic research, J. N i s c h i z a v a [7], finds the higher width- than length-values correlation between hard palate and facial dimensions. E. S e m e n o v [15], compares hard palatal dimensions to these of the facial skull and concludes their proportional relationship. In their studies on twins (aged 7–14), Y. Yordanov, and L. Tsacheva, state the closer correlations between hard palatal length and facial morphologic height; hard palatal posterior height and facial morphologic height; and hard palatal second width and cheekbone width [5].

Materials and Methods

Macerative bone materials and living individual measurements are examined.

Eight hard palatal dimensions obtained from 216 macerative adult male skulls (aged 20–43) are observed. The latter belong to dead participants in the 1913–1917 wars and are kept at the bone-vault of the Military Cemetery, Sofia.

The correlation estimating needs another 6 facial and 8 hard palatal dimensions obtained from additional 100 macerative skulls.

Morphometric analysis and growth evaluation are carried out on 829 individual plaster maxillar models, including 425 male and 404 female individuals; they are divided in 4 groups according to the individual age examined (7–9; 9–11; 12–16; and 19–25 years old).

The relationship between head, facial, and hard palatal dimensions is examined on 130 adult Bulgarian individuals, between 18–23 years of age, including 67 male and 63 female individuals.

The classic Martin – Saller anthropometric methods are used [6].The maxillar models are obtained, using plastic maxillar casts.

The morphometric studies include 8 hard palatal dimensions: 2 lengths, 4 widths (1 of them introduced by the authors), and 2 heights (1 of them introduced by the authors) (J. J o r d a n o v [10]); 7 facial skull dimensions – a cheekbone width, a foramen piriformis width, a mandibular angle width, an apical base width, an inter-processus pterygoidei width, alveolar length and width; and 4 head dimensions – an utmost length, width, a cheekbone width, and a morphological facial height.

Indices 10, describing palatal dimensions relationships, are calculated: 6 width/length indices, 2 height/length indices, and 2 height/width indices; head and facial indices.

The data procession is based on variation statistics, correlation and regression analyses.

Results and Discussion

Hard palatal absolute dimensions observed on 216 macerative adult male skulls are defined as average (Tabl. 1), excluding the higher values of distal palatal height and inter-second molar palatal width. Palatal width characterizes palatal expansion in anterior/posterior direction, the highest values found in first premolar – first molar region. The absolute values of the 8 palatal dimensions, obtained from macerative adult male skulls, and compared to other peoples' data, show that the hard palate of Bulgarians occupies an average position and have average values in human palate dimensions range [3].

T a b l e 1. Bio-statistical characteristics of hard palatal absolute dimensions of macerative adult Bulgarian male skulls, n=216

No	No after Martin	Measurements	PARAMETERS				
			X	S	V	S_x	Min- max
1	62	Basic palate length	47.40	3.35	6.50	0.21	42.0-56.0
2	62a	Outside palate length	51.36	3.37	6.56	0.23	42.8-58.8
3	Y	Second palate length	42.97	3.03	7.05	0.21	34.8-52.4
4	63_2	I-st palate width	30.17	2.40	7.95	0.16	22.8-35.8
5	X	II-nd palate width	36.39	2.74	7.53	0.19	27.8-43.8
6	63	III-d palate width	39.03	2.77	7.10	0.19	32.6-47.0
7	63_1	IV-th palate width	39.67	2.93	7.39	0.22	34.0-49.4
8	64	Posterior palate height	14.94	2.33	15.60	0.16	8.55-19.55

The obtained 10 palatal indices from macerative adult male skulls show that according to Martin's index 58, Bulgarian hard palate is mesostaphylic, with equally presented brachystaphylic and leptostaphylic cases; according to Martin's index 58a, it is brachystaphylic, too close to mesostaphylic palates. The average value of Martin's index 59 places Bulgarian hard palate in orthostaphylic palatal group.

According to height/width index, it is orthostaphylic, with predominance of equally presented orthostaphylic and hypistaphylic palates. Width/length and height/width indices confirm hard palatal expansion, i.e. that of maxillar alveolar arch, in anterior/posterior direction, the highest values found in first premolar – first molar region. This suggests a resultant connection with the process of brachycephalization in man. Width/length indices require the use of the basic palatal length. The divergence between indices, calculated on the basic and distal palatal length, is 2.5 – 6.

The obtained 11 skull dimensions (3 facial and 8 palatal) from the additional 100 macerative male skulls are processed by variation statistics, correlation and regression analyses (Tabl. 2).

The results show the highest average value is that of facial width – 108,21 mm; and the lowest average value is that of foramen piriformis – 22,44 mm.

Facial width value, compared to this of the alveolar width, shows a slight lower divergence from G. I z a r d's [2]. The dimension values of apical base are close to those, measured by N. S n a g i n a [16]. Furthermore, the main transversal dimensions data are comparative: in this assessment, facial width is a basic dimension value, less variable (i.e. more persistent) than other dimensions, in spite of the presence of some gnathofacial deformations. The changes of dimensions, different from the mentioned above, may suggest a deviation in facial skull morphology, i.e. in individual face.

The obtained data, processed by the following formula

$$K = \frac{a \times 100}{\delta}, \text{ where, for e.g. } K = \frac{\text{Facial Width} \times 100}{\text{for Piriformis Width}}$$

show:

1. Facial Width / foramen Piriformis Width = 1 : 4.9
2. Facial Width / Anterior Palatal Width = 1 : 4.5
3. Facial Width / Posterior Palatal Width = 1 : 3.3
4. Facial Width / Inter-pterygoid Width = 1 : 3
5. Facial Width / Apical Base = 1 : 2.6
6. Facial Width / Alveolar Length = 1 : 2.2
7. Facial Width / Mandibular Width = 1 : 1.8
8. Facial Width / Alveolar Width = 1 : 1.7.

Table 2. Bio-statistical characterization of the face part measurements in adult Bulgarians, $n = 100$

No	No after Martin	Parameters	X	S	S_X	min	max
1	63_2	Frontal palate width	24.08	2.84	0.28	19.0	38.0
2	$63'$	Posterior palate width	32.21	2.98	0.30	22.1	39.3
3	61	Alveolar palate width	61.20	5.28	0.53	30.0	69.4
4	60	Alveolar length	49.86	5.14	0.51	34.0	61.0
5		Width between the cuneiform prominences	36.60	3.39	0.34	29.6	46.0
6	62	Palate length	41.90	3.74	0.37	32.0	49.0
7		Apical basis upper jaw	41.22	2.90	0.29	34.0	47.0
8		Apical basis lower jaw	39.75	4.75	0.48	30.0	47.0
9	54	Pear-shaped aperture	22.44	1.80	0.18	18.0	27.0
10	46	Face width	108.21	13.18	1.32	95.4	166.0
11	66	Lower jaw width	98.66	10.89	1.09	85.2	114.0

The combined divergences of above-mentioned dimensions describe the ethnic and race skull type, while the divergences of the same dimensions in some cases show a specific deformation, in the diagnosis of which, should be taken in mind additional clinic and paraclinic examinations.

The conclusion, following the generalized analysis of the data obtained, is that they may be used as a base for adult Bulgarians facial teleroentgenography. They describe the differentiation of teeth from bone deformations or their combination in transversal direction (e.g. compression, expansion, laterognathia, hemiatrophia faciei). The obtained significant correlations in the middle facial region (maxilla) confirm the relationship between morphology and function, i.e. maxillar dimensions depend on the chewing activities and the involvement in respiratory pathways. This also proves the authors' statement about compression's occurrence because of difficult nasal breathing.

Palatal dimensions data for the 4 groups of different age, show that hard palatal bone growth in the 7 – 35 years period is in close relation and subordination to teeth eruption and teeth functions, and corresponds to the whole-body growth and development (Tabl. 3). Approximately all palatal dimensions expand most in the age of 12 to 16, pre-puberty and following puberty period in individual life, and the second molar eruption - time and growth (4). The palatal height increases most compared to the rest palatal dimensions, and this is in connection with the second molar eruption and its start to function. The inter-teeth palatal widths increase less after permanent teeth eruption. The absolute values are higher in male. The difference in dimension values for the two sexes is due to the earlier female sexual maturity and it is most prominent in the anterior and posterior palatal heights. Palatal length development increases most in puberty for both sexes, and the third molar eruption has its influence on it, too. The most appropriate age for orthodontic treatment is that of 12–16 years, when quick and significant changes in hard palatal structure take place.

The correlation coefficients describing the relationship between head, facial and hard palatal dimensions in the examined 130 adult individuals are, in most cases, higher in males. The correlation coefficient of facial cheekbone width compared to palatal width, has the highest value – 0.30 , i.e. the low limit of the average correlation. The rest of the correlation coefficients have 0.20 and 0.10 values, i.e. they are located in low correlation limit range. The facial morphological height and 4 palatal dimensions have correlation coefficients 0.20; the 4 palatal dimensions include: length, the utmost width, and both heights; the facial cheekbone width and anterior palatal width; the utmost head length and palatal length; and the utmost palatal width. The rest 3 correlation coefficients have values of 0.10. The highest 7 correlation coefficients (r=0.20) in females, compared to these 11 in males, are: the utmost head width and palatal length; facial cheekbone width and palatal length; the utmost head length and anterior palatal height.

The rest 4 coefficients have values of 0.10. The data observed show that a distinguished subordination exists between facial cheekbone width and palatal width in male individuals, while the rest dimension ratios have low, i.e. insignificant or absent correlation. Besides, the position of female and male correlation coefficients coincides in only 3 cases – two of them concerning palatal length and one – the palatal width; the rest coefficients are between different dimensions.

The evaluation of correlation coefficients between head and facial indices, on the one hand, and width/length and height/length hard palatal indices, on the other, shows that there is a relationship, although moderate (r= 0.30), between the facial morphological index and the two palatal indices for both sexes. Head index has a low correlation with palatal indices (r= 0.10 – 0.03).

The so constructed hard palatal anthropologic characteristics analysis, in accordance with the main head and facial dimensions, gives an opportunity for identifying

Table 3. Biostatistical characterization of hard palate measurement in four age groups of both sexes in Bulgarians

No	No after Martin	Teething	Age	Males, n= 425					Females, n= 404				
				X	S	V	S_X	min-max	X	S	V	S_X	min-max
1	62	6|6	7 - 9	40.70	2.44	6.00	0.30	34.6 – 45.8	40.32	2.62	6.50	0.35	36.3 – 45.2
		64|46	9 - 11	40.67	5.18	12.75	0.60	35.5 – 47.6	40.62	2.17	5.34	0.26	32.0 – 47.8
		764|467	12 - 16	47.50	2.59	5.45	0.32	39.5 – 53.0	46.53	2.92	6.26	0.34	39.0 – 52.1
		8764|4678	19 - 25	49.28	2.51	5.09	0.21	43.0 – 55.1	46.65	3.10	6.66	0.23	41.2 – 53.6
2	63_2	64|46	9 - 11	28.78	3.86	13.41	0.44	22.7 – 33.6	27.46	2.19	7.98	0.26	23.3 – 32.6
		764|467	12 - 16	28.73	2.15	7.48	0.26	23.5 – 35.1	27.23	2.64	10.01	0.31	21.2 – 33.0
		8764|4678	19 - 25	29.02	2.70	9.30	0.22	23.0 – 34.1	27.31	2.54	9.89	0.19	21.3 – 34.9
3	x	6|6	7 - 9	35.68	2.40	6.55	0.29	32.3 – 44.7	35.11	2.28	5.97	0.30	29.5 – 40.6
		64|46	9 - 11	36.63	3.16	8.86	0.36	30.5 – 42.1	35.04	2.90	8.28	0.35	30.0 – 40.0
		764|467	12 - 16	37.39	2.65	7.08	0.33	31.0 – 44.2	35.37	2.88	8.41	0.34	29.0 – 40.6
		8764|4678	19 - 25	38.33	2.39	6.24	0.22	29.0 – 45.3	35.38	2.36	6.63	0.18	26.7 – 42.5
4	63	764|467	12 - 16	42.82	2.71	6.40	0.33	35.2 – 50.0	41.15	2.68	6.51	0.31	34.2 – 48.1
		8764|4678	19 - 25	43.04	2.28	5.30	0.21	34.1 – 56.0	41.30	2.73	6.80	0.20	31.8 – 48.1
5	64_a	64|46	9 - 11	15.08	1.21	7.37	0.28	13.0 –18.5	14.41	1.14	9.78	0.28	11.4 – 19.1
		764|467	12 - 16	16.06	2.22	13.82	0.31	12.6 – 20.3	16.15	2.52	15.35	0.32	11.0 – 20.0
		8764|4678	19 - 25	15.79	2.52	14.96	0.24	10.2 – 23.1	15.23	2.77	18.19	0.21	10.2 – 20.0
6	64	6|6	7 – 9	12.70	1.41	11.10	0.17	10.0 – 16.4	12.90	1.03	7.41	0.14	10.5 – 16.5
		64|46	9 - 11	13.12	1.36	10.36	0.16	9.5 – 16.4	13.90	0.30	18.60	0.30	9.0 – 18.8
		764|467	12 - 16	15.60	1.22	7.82	0.15	11.4 – 19.2	15.53	1.86	11.98	0.22	11.0 – 19.0
		8764|4678	19 - 25	17.61	2.44	13.86	0.12	12.0 – 24.5	16.64	3.21	19.29	0.24	11.0 – 21.1

the normal and abnormal cases and it helps prophylaxis, diagnosis and treatment of a part of dento-occlusial abnormalities [14, 17, 18]. The close values of correlation coefficients to these of the other head dimensions, respectively these of the human face, confirm the significant and established role of growth and development of teeth follicles, teeth, and teeth rows in human hard palatal morphologic characteristics.

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