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SPECIFIC FEATURES OF VARIANT ANATOMY AND MORPHOMETRIC CHARACTERISTICS OF THE PALATAL VAULT IN ADULTS WITH DIFFERENT GNATHIC AND DENTAL TYPES OF ARCHES

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Taisiya Kochkonyan[1], Ghamdan Al-Harazi[2], Dmitry Domenyuk[3]✉, Sergey Dmitrienko[4], Stanislav Domenyuk[5]

[1] *Kuban State Medical University, Krasnodar; Russia;*
[2] *Sana'a University, Sana'a, Yemen;*
[3] *Stavropol State Medical University, Stavropol, Russia;*
[4] *Volgograd State Medical University, Volgograd, Russia;*
[5] *North Caucasus Federal University, Stavropol, Russia*

✉ *domenyukda@mail.ru*

ABSTRACT — Cone-beam computed tomograms of 68 people (age — 21–35) with physiological occlusion and various gnathic dental arches were analyzed by a method developed for identifying the palatal arch index, taken as a height (depth)-to-width dimension ratio. The results of the study revealed that palatal parameters are determined by main variants (types) of the palatal vault. In case of the mesopalatal type of the arch (index value — 35–45%), the width parameters exceeded the depth values by an average of 2.4 times, while the divergence angle of alveolar processes was 116.7 ± 5.6°. The dolichopalatal type of the arch (index value – above 45%) featured domination of the width parameters over the depth-related ones, by an average of 1.8 times, while the alveolar processes divergence angle made up 127.6 ± 6.1°. As far as the brachypalatal type of the arch is concerned (index value — below 35%), the width parameters exceeded the depth parameters by 4.0 times on average, the divergence angle of the alveolar processes being 113.5 ± 5.3°. The obtained data can be used in clinical orthodontics when diagnosing pathologies of the palatal vault, as well as to interpret data from additional methods of examination and to choose the right treatment for issues related to the dental arch shape and size.

KEYWORDS — dentofacial system; upper jaw; types of palatal vault, cone-beam computed tomography, hard palate, alveolar process, dental arches.

INTRODUCTION

Modern dentistry and maxillofacial surgery, as rapidly developing areas of medicine has witnessed growing importance of X-ray-based diagnostics methods. The high research and applied value of these methods, which is due to improved X-ray and computed technologies, offer a new perspective in evaluating diagnostic data of dental patients in different age. [7, 18, 20, 24, 30, 37, 48].

The constantly growing share of plastic and reconstructive interventions in maxillofacial surgery and surgical dentistry makes it relevant to study individual features of the jaw structure [5, 13, 16, 22, 36]. In this connection the upper jaw shape and morphometry variability present the basic point when dealing with orthodontic and orthopedic treatment methods [6, 19, 25, 29, 34, 40, 54]. Respective literature shows that a detailed study of the maxillary processes, firstly, is of fundamental theoretical significance, and secondly, has an applied value in identifying pathological changes of the maxillary system, in interpretating X-ray data, as well as in arranging treatment and rehabilitation for dental patients [1, 11, 23, 35, 41, 47, 53]. The palate, which is the boundary between the oral cavity and the nose, is closely related to the development of the dentoalveolar system, as well as the skull as a whole. The alveolar process in regard to its topographic location has a particular importance for clinical disciplines [2, 17, 32, 44]. The palatal vault is an anatomical structure shaped by the hard palate bones (the palatal processes of the upper jaw and the horizontal plates of the palatal bones) and the palatal parts of the alveolar processes [28, 50]. The bone palate shape and size correlate with the dental arch parameters in different directions. Besides, relationship between the size of the dental arches and the parameters of craniofacial complex is established and modern classifications for dental arch types are proposed [4, 12]. Specific features of maxillofacial parameters in view of sex dimorphism and racial differences are shown [21, 27].

Specifics of the hard palate morphology have been studied in multiple works focusing on diagnosing and treating congenital anomalies, namely, cleft palate and issues affecting alveolar processes, hard and soft palate [3, 49, 57].

The influence of the growth type for the gnathic face part and the dental arch morphometric parameters in occlusion anomalies in the sagittal and transversal directions was shown. This has a significant impact on the palatal arch configuration. Special features of tooth rotation were identified as well as their effect on the dental arch shape and parameters [31, 33, 52].

Currently, there are plenty of methods available for studying the maxillofacial area, including the palatal arch [15, 26, 51, 56]. Among the research methods, special attention is paid to such methods as X-ray cephalometry, cone-beam computed tomography, and electron microscopy [8, 14, 38].

To assess the palatal arch parameters, there is an index proposed, which is calculated as the palate depth-to-width ratio, while a digital factor of 31–32% is recommended for identifying the norm at a young age. However, in these studies there are no data on variability of shape of the dental arches, as well as the dental arch width and the apical basis have on the palatal arch parameters [10, 45]. The specific features of the palatal arch are often the factors that determine orthodontic and prosthetic tactics for treating patients with various maxillofacial pathologies [9, 39, 43, 55].

There are certain results available, revealing changes affecting the palatal arch though orthodontic treatment offered to patients with distal occlusion [42, 46]. However, the authors in the above studies showed no hard palate parameter variability for different types of dental arches, nor did they point at the severity of the alveolar process divergence in relation to the palatal part of the arch, which, in turn, was the aim of this current study.

Aim of study:

to determine specific features of the alveolar process divergence angle in people with different morphometric palatal arch parameters.

MATERIALS AND METHODS

A retrospective study was conducted, where cone-beam computed tomography (CBCT) scans of 68 patients (aged 21–35, with physiological occlusion and various gnathic, dental types of dental arches) were studied. The CBCT images were used to evaluate the palatal arch parameters at the deepest areas, usually at the level of the second premolars. The transversal dimensions were identified in three main positions. First, the dental arch width between the vestibular odontomers (tubercles) of the second premolars at the occlusal contour was measured. The second measurement was performed to identify the width of the palatal arch alveolar part. The measurement was done between the points located on the second premolar neck on the palatal side of the arch. The third measurement in the transversal direction was aimed at identifying the width of the palatal part of the arch. The measurement was performed between the points where the alveolar processes join the palatal processes of the upper jaw.

The palate height was determined from the palatal arch deepest point to the line connecting the necks of the second premolars lingual surface.

The obtained linear parameters allowed determining the palatal arch index taken as a ratio of the palate height (depth) to the width of the alveolar part. The index helped identify three groups. IN case of an index value ranging within 35% to 45%, the palatal vault was classified as *mesopalatal*, with 25 tomograms analyzed within the group.

An increase in the index pointed at a palatal arch belonging to the deep (dolichopalatal) type, where 21 tomograms were analyzed. A decrease in the index was typical of the low (brachypalatal) type, which was detected on 22 tomograms.

Apart from the *palatal arch index*, the parameters of the *palatal arch module* were calculated as half-sum of the palate height and the width of its alveolar part. Further, the alveolar process divergence angle was identified in relation to the width of the palatal part of the arch.

The statistical data processing relied on the Microsoft Excel 2013 software and the statistical SPSS Statistics (Version 22) software package. The critical level of possible null statistical hypothesis was set at 0.05.

RESULTS AND DISCUSSION

The morphometric analysis of cone-beam computed tomograms revealed that the palate parameters are determined by the major types of the palatal arch (Table 1).

The results of the study showed the specific features of the alveolar process divergence angles in people with different palatal arch types. During that, there were some differences noted in the morphometric parameters of the investigated anatomical area.

The main indicator of the palatal arch type was its index, which, with an average size, varied from 35% to 45%, which corresponded to the *mesopalatal* type. In the *dolichopalatal* type, the palate index was above 45% reaching an average of 54.84±2.76%. People with the *brachypalatal* type featured an index below 35% — 24.87±1.29% on average.

Patients with the *dolichopalatal* type of the arch had a difference of 17.7 ± 0.9 mm in the size between the transversal dimensions of the alveolar and palatal processes, which determined the divergence angle of the alveolar — 127.6 ± 6.1 degrees on average (Fig. 1).

***Table 1.** Main parameters of the dental arches and the palatal arch in the studied group, (M±m), (p ≤ 0.05)*

Dental arch and palatal parameters at the level of the second premolars	Variants of palatal vault		
	deep	low	average
Dental arch width (mm)	46.4 ± 2.1	51.6 ± 2.7	45.4 ± 1.9
Palatal arch width (mm)	13.3 ± 0.7	23.3 ± 1.1	19.1 ± 0.8
Alveolar part width (mm)	31.0 ± 1.3	38.2 ± 1.6	32.8 ± 1.5
Palatal vault depth (mm)	17.0 ± 0.6	9.5 ± 0.3	13.7 ± 0.4
Palatal vault index (%)	54.84 ± 2.76	24.87 ± 1.29	40.53 ± 1.95
Palatal vault module (mm)	24.0 ± 0.9	23.85 ± 0.74	23.25 ± 0.69
Palatal vault angle (degrees)	127.6 ± 6.1	113.5 ± 5.3	116.7 ± 5.6

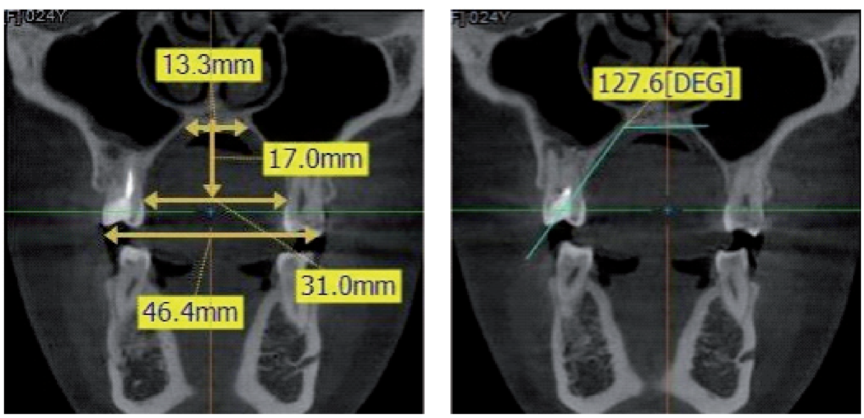

***Fig. 1.** Main parameters of the dolichopalatal arch type at the second premolars level*

The width of the palatal part of the arch in people with the *dolichopalatal* type was 13.3 ± 0.7 mm, whereas the alveolar part, at the level of the tooth necks, was 31.0 ± 1.3 mm. The depth of the palatal arch was 17.0 ± 0.6 mm, the palatal arch module being 24.0 ± 0.9 mm.

In people with the *brachypalatal* type of the palatal arch, the difference in size between the transversal dimensions of the alveolar and palatal processes was 12.9±0.5 mm, which determined the value of the alveolar process divergence angle, 113.5 ± 5.3 degrees on average (Fig. 2).

The width of the palatal part of the arch in people with *brachypalatal* type was 23.3 ± 1.1 mm, which is significantly above that in people with a deep palate ($p<0.05$).

The width of the alveolar part, at the level of the tooth necks, was 38.2 ± 1.6 mm. The depth of the palatal arch was 9.5 = 0.3 mm. At the same time, the palatal arch module was 23.85 ± 0.74 mm and featured basically no difference from the index observed in people with the dolichopalatal type of the arch ($p<0.05$).

In people featuring the *mesopalatal* type of the palatal arch, the difference in size between the transversal dimensions of the alveolar and palatal processes was 14.7±0.6 mm, which determined the divergence angle of the alveolar processes — 116.7 ± 5.6 degrees on average (Fig. 3).

The width of the arch palatal part in people with the mesopalatal type was 19.1 ± 0.8 mm, and the alveolar part, at the level of the tooth necks, was 32.8 ± 1.5 mm. The depth of the palatal arch was 13.7 ± 0.4 mm, while the palatal arch module was 23.25 ± 0.69 mm.

Given the above, identification of the alveolar process divergence angle in people with different palatal arch morphometric parameters using advanced X-ray-based methods should be a mandatory item in orthopedic dentistry and orthodontics at stages like comprehensive examination, selecting the tactics for assisting patients with dentoalveolar issues, as well as when assessing the effectiveness of dental treatment (rehabilitation).

CONCLUSION

1. The data obtained through studying cone-beam computed tomograms of patients with a complete set of permanent teeth and a physiological occlusion point at a relationship between the palatal arch morphometric parameters (height, depth) and

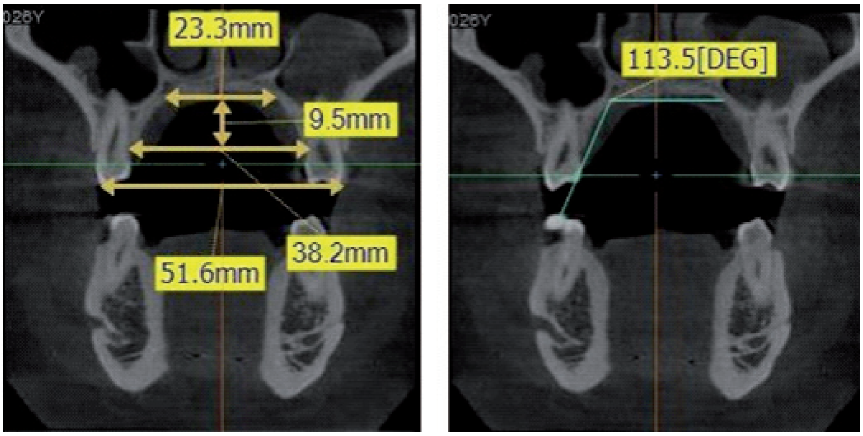

***Fig. 2.** Main parameters of the brachypalatal arch type at the second premolars level*

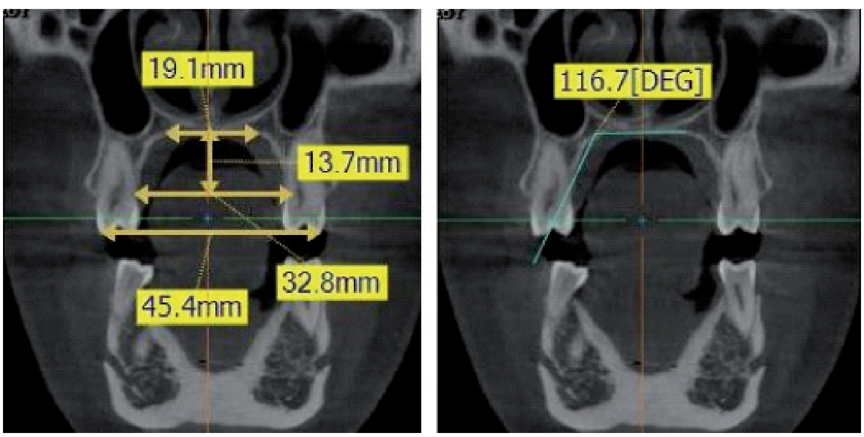

***Fig. 3.** Main parameters of the mesopalatal arch type at the second premolars level*

the width-related dimension values of the dental arches. The type (brachy-, meso-, dolichopalatal) of the palatal arch is determined by index values taken as the palatal arch height (deep)-to-width ratio values.

2. For the mesopalatal arch, featuring an index varying within the range of 35–45%, which in linear dimensions points at the width parameters prevailing over the depth values by an average of 2.4 times, the difference in size between the transversal dimensions of the alveolar and palatal processes was 14.7±0.6 mm, whereas the value of the alveolar process divergence angle was 116.7 ± 5.6°.

3. In case of the dolichopalatal arch, with the index exceeding 45%, which in linear dimensions indicates the prevalence of the width parameters over the depth parameters, on average by 1.8 times, the difference in size between the transversal dimensions of the alveolar and palatal processes was 17.7±0.9 mm, the alveolar process divergence angle being 127.6 ± 6.1°.

4. In case of the brachypalatal type of the palatal arch, where the index is below 35%, meaning in linear dimensions a prevalence of the width parameters over the depth parameters by an average of 4.0 times, the difference in size between the transversal dimensions of the alveolar and palatal processes was 12.9 ± 0.5 mm, while the divergence angle of the alveolar processes was, on average, equal to 113.5 ± 5.3°.

5. The palatal arch module value, which was taken as the ratio of half-sum of its height (depth) parameters to the width of the alveolar part, in the mesopalatal type was 23.25 ± 0.69 mm, while for the dolichopalatal and brachypalatal types the values were 24.0 ± 0.9 mm and 23.85 ± 0.74 mm, respectively.

6. Cone-beam computed tomography, which features specificity, high sensitivity, and low radiation load, allows obtaining the most reliable diagnostic information concerning the cranio-facial complex bone structures. Improving the visualization algorithms, analysis of cranio-facial complex bone structures, in view of the patient's individual features, will allow standardizing methods of dental research, as well as modifying the conventionally accepted systems for the respective data analysis and interpretation, thus helping setting reliable diagnosis to patients with congeni-

tal anomalies (cleft lip, alveolar process, hard and soft palate), as well as occlusion anomalies and deformities in the sagittal and transversal directions.

7. The inclusion of the palatal arch index values in people with physiological types of occlusion and various types of dental arches in the *Clinical protocols for diagnosing and orthodontic treatment of dental anomalies in outpatient conditions* will help reduce the time spent by orthodontists on clinical examination and diagnosing, enhance the diagnosing reliability for dental issues, and improve the planning of orthodontic treatment stages for patients in their period of permanent teeth occlusion.

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