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MORPHOMETRIC PATTERNS OF MAXILLARY APICAL BASE VARIABILITY IN PEOPLE WITH VARIOUS DENTAL ARCHES AT PHYSIOLOGICAL OCCLUSION

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ABSTRACT — Morphometric data on the structure of the craniofacial complex are reliable and diagnostically significant values that are of applied nature in terms of practical dentistry. Within this study, analysis of cone-beam computed tomograms, biometric indicators of plaster models obtained from the jaws of 83 people (aged 21–35) with physiological occlusion and various types of dental, gnathic dental arches, the degree of proportion between the maxillary apical base and the inter-canine distance were identified. Depending on the dental arch type, the patients were divided into three groups. The morphometric study in the CBCT frontal plane was the distance between the canines tearing tubercles and the inter-canine distance in the apical area. The study outcomes revealed discrepancies between the calculated and actual indicators of the apical base width for all types of dental arches in people with physiological occlusion. In case of mesotrusive dental arches (incisional angle — 127–143°), the width of the apical base corresponded to the width of the dental arches between the canines, while the differences in indicators were not statistically significant. In people with retrusive dental arches (incisional angle exceeding 144°), the width of the dental arch was found to be significantly above the width of the apical bases. As far as protrusive dental arches are concerned (incisional angle below 126°), these patients featured predominance of the apical bases width over the inter-canine distance. The obtained data add to that already available in research literature regarding the relationships and dimensional features pertaining to the craniofacial complex structures, as well as have applied value in orthodontic clinical practice.

KEYWORDS — morphometry, maxillary apical base, cone-beam computed tomography, inter-canine width of the dental arch, physiological occlusion, dental arch, craniofacial complex.

INTRODUCTION

Studying the craniofacial structures should be performed from the individual and age-related variability stance. This area allows, in each specific case, identifying the features of the structure and the position of a particular anatomical area in the craniofacial complex relying on a set of signs [3, 8, 14, 18, 21, 23, 36, 44]. Given that, studying the relationship between dental arches and craniofacial parameters is an urgent issue, which is associated with employing advanced orthodontic technology in treating patients with various dentition and occlusion issues [2, 9, 16, 19, 25, 32, 41, 47].

The attention focus, for both anatomists and clinicians, is dental arches. On the one hand, they are involved in the development of the facial area of the skull, while on the other — they are the object of manipulation for orthodontic and orthopedic dentists. The data obtained through investigating the variant anatomy of dental arches serve the basis for comprehending the patterns involved in the structural arrangement of the facial area of the skull as a whole [10, 12, 20, 22, 26, 35, 54].

The apical base of the jaws is an anatomical structure, defined as a conditional line connecting the tops of the teeth roots. In clinical orthodontic practice, measurements of the length and the width of the apical base are an inevitable part of diagnosing maxillofacial anomalies and deformities [1, 4, 7, 24, 48]. The main methods used for assessing the parameters of the apical base mentioned by Howes and N. G. Snagina can be seen from respective manuals and textbooks on orthodontics and are based on measuring the width of the 12 teeth crowns [5, 11, 27].

The apical base width has been proven to be determined by the teeth inclination in the vestibular-lingual direction, which in orthodontics is called the teeth torque. In view of this, quite logical is to conclude that at high torque values, the tooth crown is inclined more towards the vestibular side, while the root is more inclined towards the lingual side, if compared to cases of low inclination angle values. The torque values for various types of physiological occlusion are available in respective works published by most specialists [6, 17, 42, 45, 49].

As the authors claim, the parameters of the apical base width depend on the anatomical facial features. There has been a direct dependence shown between the width of the maxillary apical base and the morphological width of the face. Notable is that this work offers data in view of the face belonging to the wide, medium or narrow types, with no regard as to the gnathic features of the maxillofacial area [31].

Literature offers information showing that people with the brachygnathic type, have a wider shape of the upper dental arches in the transversal, and shorter – in the sagittal plane, if compared to mesognathic dental arches [30]. Research involving people with dolichognathic types showed a whole opposite situation, namely, the upper dental arches were shorter in the transversal plane and longer in the sagittal, if matched against mesognathic dental arches [34, 37]. However, in the studies mentioned above the authors offer no details on the parameters of the apical base in persons with different types of face and dental arches.

There are some advanced approaches to studying dental and alveolar arches, including cone-beam computed tomography, presented [13, 28, 39, 50]. These approaches are recommended for their use in clinical dentistry to diagnose respective pathologies and guide the treatment choice [33, 38, 43]. During that, there is no data on the size of the apical bases and their relationship with the width of the dental arch between the canines, which explains the aim of this study.

Aim of study:

to identify the proportion of the maxillary apical base to the inter-canine distance in people featuring various types of dental arches with physiological occlusion.

MATERIALS AND METHODS

A stratified retrospective study was carried out, where cast models and cone-beam computer tomograms (CBCT) were studied as obtained from 83 patients within their first mature age (21–35 y.o.) with physiological occlusion and various gnathic dental types of arches. The entire body of patients was broken into groups in view of the dental arches erosive type. 29 of the patients had mesotrusion, another 26 — protrusion, with 28 more featuring a retrusive type of dental arches.

The type of dental arch was identified subject to the incisional angle on tomograms. An incisional angle ranging between 127 and 143° corresponded to the mesotrusive type of dental arches. An increase in the incisional angle making it finally exceed 144°, allowed attributing the respective dental arches to retrusion, whereas a decrease in the angle reducing it to below 126° allowed including the dental arch to the protrusive type (Fig. 1).

The proposed criteria are in line with the data mentioned by the majority of experts studying the features of dental arches in case of physiological occlusion [29, 46, 51, 52, 55].

The levels of the canines and apical bases were identified through the CBCT in the transversal plane in the projection of the roots between the canines and the first premolars. Further, the distance between the canines cutting tubercles in the apical area was measured on the CBCT in the frontal plane (Fig. 2).

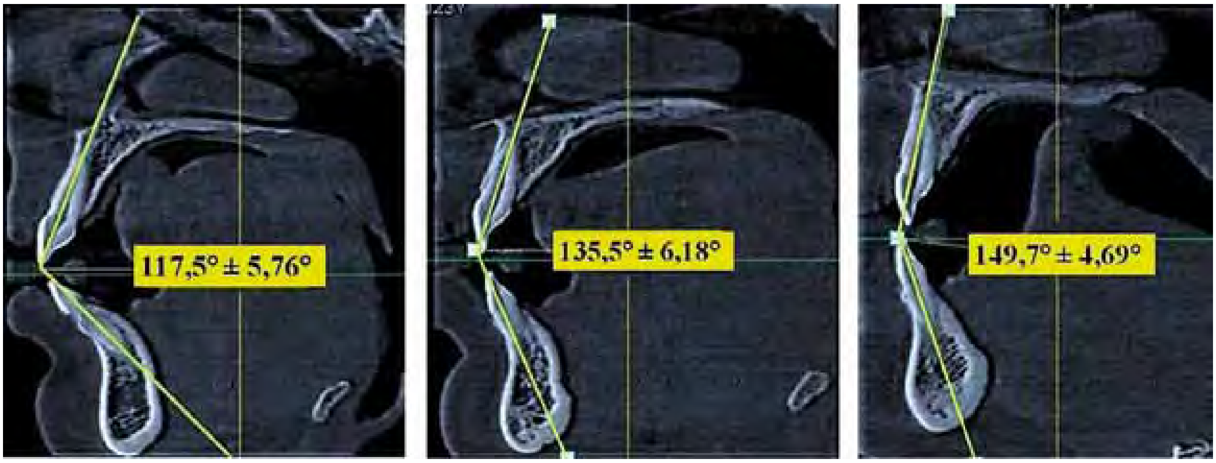
The study implied investigating the biometric indicators of jaw cast models. The odontometric measurements focused on evaluating the total width of the crowns of 14 and 12 teeth that make up the dentition. The sizes of 6 front teeth were measured. The odontometric data was used to calculate the types of dental arches, thus to determine whether the dental system belongs to the macro-, micro- or normodental type. Besides, the total size of the 12 upper teeth allowed calculating the apical base width, which normally (Snagina N. G., 1965) made up 44% of the obtained value. In the upper jaw models, the apical base was detected in the root tips projection between the canine and the first premolar. The actual value was compared with the calculated values for all types of dental arches.

The width of the dental arches between the canines was measured, where the points on the tearing tubercles were the landmarks. The dental arch width between the second molars was measured between the distal tubercles of the antimeres.

The statistical data processing was done with the Microsoft Excel 2013 software as well as employing the package of the SPSS Statistics software (version 22). The critical level of a possible null statistical hypothesis was taken as equal to 0.05.

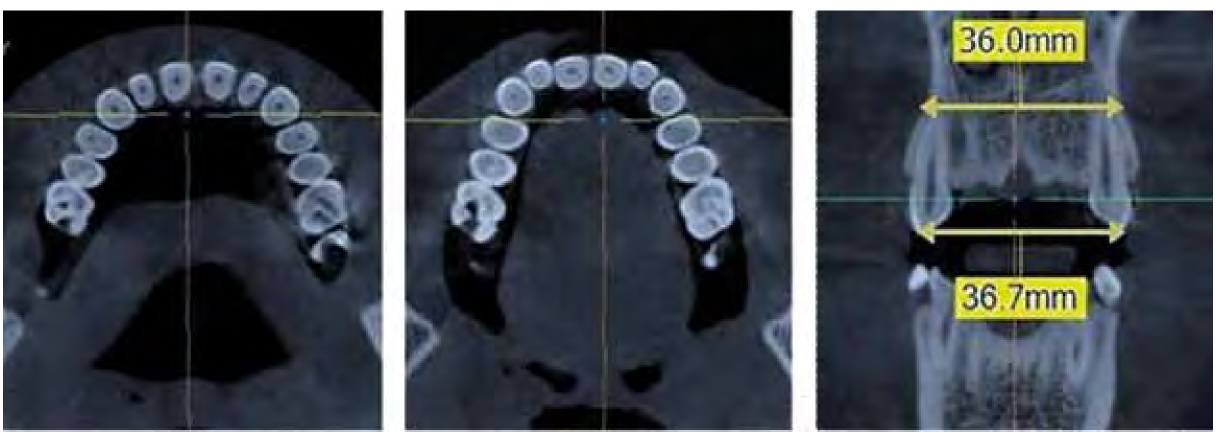
RESULTS AND DISCUSSION

A morphometric analysis of cone-beam computed tomograms and biometric indicators of the jaw cast models revealed that in case of physiological occlusion, the length of the dental arch, calculated as the sum of the width of the 14 teeth crowns, featured statistically significant differences depending on the type of arches. People with the protrusive type of dental arches, for instance, had the parameter in question significantly exceeding that in people with retrusion. This can be accounted for by the fact that in case of the protrusive arches, macrodontic dental arches were more common, while with the retrusive type the common type of dental arches was that of microdontia. Given that, the odontometric parameters of the 12 teeth and the 6 front teeth of the upper jaw featured certain differences, which can be seen from Table 1.



a b c

Fig. 1. Images of the CBCT fragments with printed results of the incisional angle in case of dental arch protrusion (a), mesotrusion (b) and retrusion (c)



a b c

Fig. 2. The level of the CBCT sections aimed at identifying the canine distance (a) and the apical base (b) of the upper jaw, as well as the method for measuring the respective parameters (c)

Table 1. Transversal dimensions of the dental arches and apical bases (AP) of the upper jaw in people with physiological occlusion (M±m), (mm), ($p \leq 0.05$)

Upper arch parameters	Size parameters at various arch types:		
	mesotrusion	protrusion	retrusion
Sum of 14 teeth	112.88±2.54	119.88±2.21	109.82±2.37
Sum of 12 teeth	93.70±2.06	99.31±1.98	90.89±2.13
Sum of 6 front teeth	46.63±1.18	48.68±1.32	44.93±1.09
AP calculated width	41.23±0.21	43.70±0.29	39.99±0.27
AP actual width	37.69±0.24	35.41±0.27	38.14±0.22
Width between the canines	37.22±0.27	35.96±0.28	36.72±0.25
Width between molars	60.62±1.49	63.02±1.54	63.30±1.62

In view of the differences in the total size of the 12 teeth, the differences in the apical bases calculated width in people with different types of dental arches were identified.

In people with the mesotrusive type of dental arches, where the total width of the 12 teeth crowns is 93.70±2.06 mm, the width of the apical bases, according to N. G. Snagina, should make up an average of 41.23±0.21. During that, the actual value measured on the models was 37.69±0.24 mm. The difference between the calculated and the actual values of the apical base width was 3.54±0.12 mm.

In people with protrusive dental arches, with the sum of the crowns width of the 12 teeth is 99.31±1.98 mm, the estimated width of the apical bases was 43.70±0.29 mm on average. The actual value, though, measured on the models, was 35.41±0.27 mm. The said difference between the calculated and the actual value was 8.3±0.17 mm, which exceeded significantly that in people with the mesotrusive type of dental arches ($p \leq 0.05$).

As for people with the retrusive type of dental arches, where the sum of the crowns width of the 12 teeth was 90.89±2.13 mm, the apical bases estimated width was 39.99±0.27 mm. At the same time, the actual value measured on the cast models was 38.14±0.22 mm. This *the calculated vs. the actual value* difference in the apical base width was significantly smaller ($p \leq 0.05$) than in the other study groups, making up 1.85±0.41 mm.

Special attention has been paid to the differences between the width of the apical base and the width of the dental arch in between the canines. The difference in size has been shown to depend on the type of dental arches (Fig. 3).

the difference in size being 0.47±0.19 mm. We have detected no significant difference between the width of the apical base and the inter-canine distance ($p \geq 0.05$).

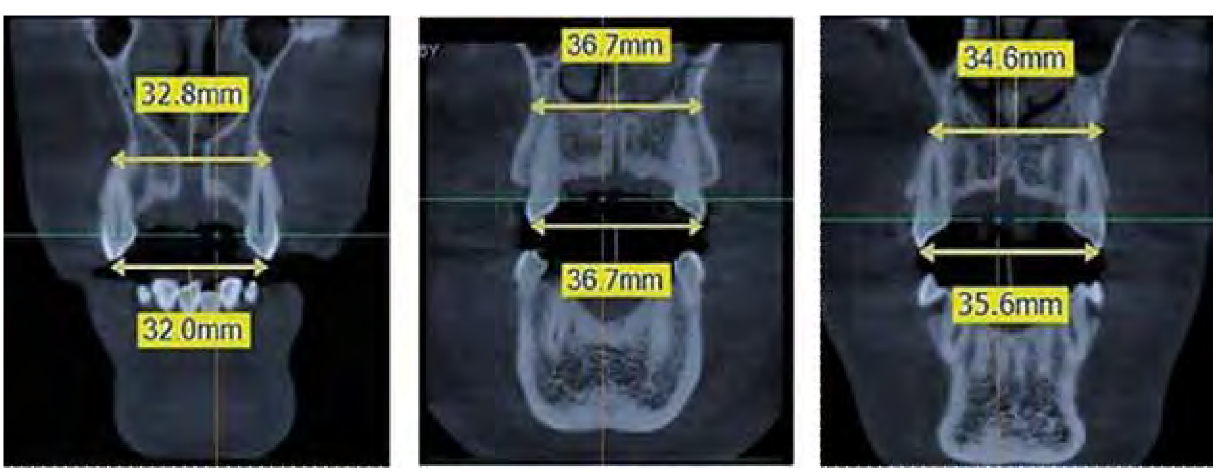
The actual value of the apical bases in the retrusion types of arches exceeded the value of the inter-canine distance (36.72±0.25 mm), whereas the size difference was 1.43±0.31 mm.

The actual value of the apical bases in case of the protrusive types of dental arches, in contrast to patients with the other types of arches, was smaller than the width of the dental arch between the teeth (35.96±0.28 mm), with the difference in size being 0.55±0.13 mm.

The outcomes of the study, therefore, revealed that there was a mismatch between the calculated and the actual indicators of the apical base width for all types of dental arches in people with physiological occlusion. The largest mismatch value, namely, 8.3±0.17 mm, was to be observed in those featuring the protrusive type of dental arches, the distinctive for them being *high* values of the canine torque, which is consistent with the opinion expressed by respective specialists [15, 40, 53, 56].

The differences between the calculated and the actual parameters of the apical base width were the smallest in people with the retrusive type of dental arches, the average difference making up 1.85±0.41 mm.

During that, the transversal dimensions of the maxillary apical bases proved to be close to the dimensions of the dental arches between the canines, yet



a *b* *c*

Fig. 3. *The relationship between the apical base size and the inter-canine distance in people with dental arches belonging to the retrusive (a), mesotrusive (b) and protrusive (b) types*

The actual value of the apical bases in case of mesotrusive dental arches (37.69±0.24 mm) was close to the value of the inter-canine distance (37.22±0.27 mm) there were certain differences in the morphometric parameters of the studied groups.

CONCLUSION

1. The data obtained through studying biometric indicators of jaw cast models and cone-beam computed tomograms of patients with a full set of permanent teeth, physiological occlusion and various gnathic dental types of arches, point at a proportion between the morphometric parameters of the maxillary apical base width and the inter-canine distance.

2. In people with the mesotrusive type of dental arches, the actual width of the apical base (37.69±0.24 mm) matches the width of the dental arches between the canines (37.22±0.27 mm), whereas the difference in indicators does not come up to statistically significant values ($p \geq 0.05$).

3. Patients with the retrusive type of dental arches have the apical base actual width (38.14±0.22 mm) exceeding statistically ($p \leq 0.05$) the width of the dental arches between the canines (36.72±0.25 mm), while the difference in size is 1.42±0.31 mm.

4. In people with the protrusive type of dental arches, the apical base actual width (35.41±0.27 mm) falls slightly below the value of the width of the dental arches between the canines (35.96±0.28 mm), the size difference being 0.55±0.13 mm.

5. Further advance of algorithms employed to study the variant anatomy of dental arches, the apical bases of the jaws in the cranial structure, in view of the patient's individual features, would allow standardizing the methods of dental research, as well as modifying the generally accepted analysis and interpretation systems of the data obtained for reliable identification of patients with abnormal and deformed dental system.

6. The calculated data on the proportion of the maxillary apical basis and the inter-canine distance in people featuring different dental arches and physiological occlusion allow systematizing craniometric and odontometric study outcomes, obtaining reliable significant information on the patterns of the dental arch structure and their compliance with the morphometric specifics of the maxillofacial area, whereas such data is of value for research and clinical practice.

7. The inclusion of information on the existing (lacking) mismatch between the apical base width and the inter-canine distance in people with physiological occlusion and various types of dental arches into the *Clinical protocols for the diagnosing and orthodontic treatment of dental anomalies in outpatient setting* will help reduce the time spent by orthodontists through various stages of clinical examination and diagnostics, increase the effectiveness of the diagnosing dental issues, optimize the planning of orthodontic treatment, in particular, determine the location of the permanent canines in a position matching the apical base size.

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