SHAPE INDIVIDUALIZATION IN LOWER DENTAL ARCHES DRAWN ON BASIC MORPHOMETRIC FEATURES

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ABSTRACT
The dentoalveolar arch was constructed by connecting the dots of the lingual alveolar arch in the anterior part (between the distal surfaces of the mandibular canines) and the middle point of the distal surface of premolars and molars' occlusal contour. The width of the dentoalveolar arches was measured between the second molars while its depth was determined as a distance from the frontal vestibular point to the line connecting the corresponding points of the second molars along the projection of the median palatal suture. The frontal distal diagonal of the dentoalveolar arches was found to be the key parameter which allows determining whether or not the teeth size matches the dentoalveolar arch measurements.

KEYWORDS — vestibular dental arch, alveolar lingual arch, alveolar palatal arch, dentoalveolar arch, physiological occlusion.

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Nowadays the progress in clinical dentistry can be described with a high level of fundamental and applied research related to morphogenesis, as well as generic and individual variability in the morphological structures of the dento-facial region. Yet, despite the large scale of the research projects carried out both nationally and abroad, there are still numerous aspects pertaining to this complicated issue that remain unresolved [11].

The dento-facial region is part of the body which undergoes dynamic changes through its growth and development, which has been the focus of many works by Russian and foreign authors. The issues relating to the link between the sizes of the dental arches and the structural features of the jaws and the craniofacial complex on the whole, have acquired some particular relevance lately, which, above all, could be accounted for by an expanded range of the reasons behind the indications for orthodontic treatment [1,4].

The society nowadays is paying more and more attention to the human face and the balance in its structure. There is a certain dependency between the shape and size of the dental arches and the face, where-as identification of misbalance may help identify the disorder. The shape of the face has been found to be subject to an impact form the dimensions of the facial and partially brain skull, their positional relationship, as well as the dimensions and the arrangement of the soft tissues in the dento-facial area [5,9].

An integrated analysis of the respective research has demonstrated both Russian and foreign scientists pay currently rather serious attention to various points connected with the match of the permanent teeth sizes and the craniofacial complex' parameters, and the dental arches in particular. The concept of the "ideal" match for the parameters in question may prove a useful tool for an Orthodontist when diagnosing anomalies and selecting the treatment options since there is a biological basis for that [7].

Both Russian and foreign literature nowadays offers overviews of numerous research projects specifically focusing on the anatomy of the dento-facial region taking into account the racial and gender features,

as well as on the variability of the dento-facial system for different somatotypes. There is also quite detailed description available on the shape of the teeth and the dental arches based on a particular somatotype [10].

Among the paramount tasks for Orthodontics we could mention stable functional and aesthetically acceptable shape of the dental arch, and the key point in reaching the aim here is a search for the ideal shape of the dental arch appropriate per each clinical case [2]. For over a century now researchers have been trying to decide on the ideal shape of the dental arch exploiting the idea of its symmetry and compliance with rules of Mathematics and representing it through algebraic or geometric formulae [3,8].

Today, one of the most popular ideas holds about an individual choice of the dental arch shape subject to the original arch of the mandibula. Given the progress in computer analysis, this approach to an individualized design for the arch form may contribute to developing an optimal solution regarding the proper choice of the arch through all the stages of orthodontic treatment [6].

While steel arches may solve the issue due to individual preformation of the standard (or the closest in size) arches manufactured industrially, altering the shape in the standard nitinol arches appears quite a concern. Therefore, identifying the major clinical forms of dental arches for developing industrial arcs that would stand similar to them yet remains an urgent question in Orthodontics.

Purpose — to investigate the clinical variants and the basic morphometric parameters of the lower dental arches in their shape variations.

A comprehensive analysis of the relationship between the sagittal and the transversal sizes of dental arches was held involving 309 patients (146 men and 163 women) in their early adulthood who revealed physiological occlusion of the permanent teeth. Three types of dental arches have been proposed for the evaluation: the dental vestibular arch, the alveolar lingual arch, and the dentoalveolar arch. The cast models of the lower jaw were dotted in order to construct and perform morphometric measurements in the dental arches. When studying the dental arch, the main points were set in the middle of the vestibular surface of the incisors, canines and premolars' occlusal contour (the most prominent part in the vestibular contour of the tooth crown' occlusal surface); the most protruding points on the vestibular contour' occlusal surface of the vestibular distal cusps were marked on the molars. The alveolar lingual arch was formed through connecting the dots located at the lingual surface of the dental arch in the interdental spaces. When constructing and measuring the dentoalveolar arch the dots were set in the middle of the teeth crowns' distal surface in proximity to the occlusal contour (Fig. 1).

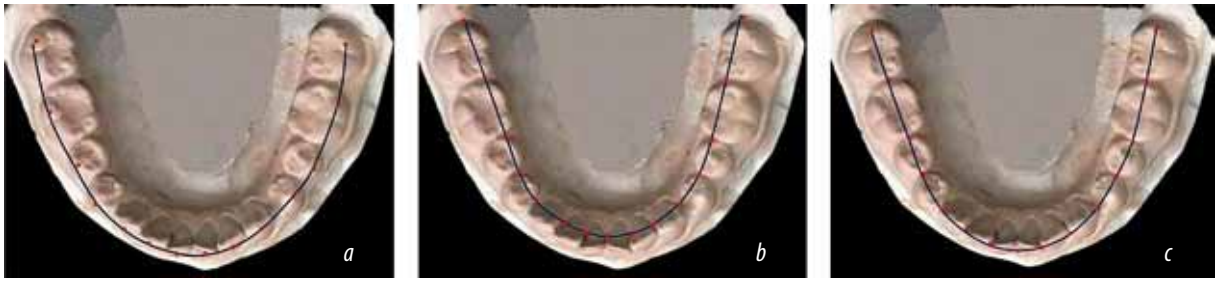

Fig. 1. *Cast models with the contours of the dental arch (a), the alveolar arch (b), and the dentoalveolar arch (c)*

The key parameters for measuring the dental arch included its length, width, and depth as well as the frontal distal diagonal (Fig. 2).

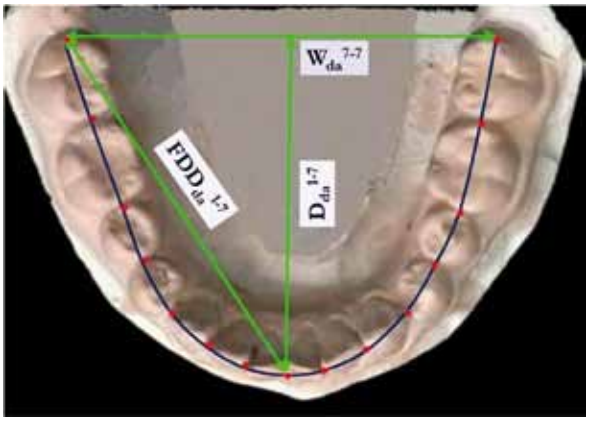

Fig. 2. *Mandibular cast model bearing the contour of the dentoalveolar arch and the key parameters to be measured*

The longitudinal length of the dentition was detected through the Nance method as a sum of the mesial distal diameters of the compounding teeth. The third molars were not included in the measurements due to their being the most variable ones. When measuring the dental arch and the dentoalveolar arch, the frontal vestibular point was arranged amidst the medial incisors. The width of the mandibular arches (dental arch, dentoalveolar arch, and alveolar arch) was measured between the second molars (W_d^{7-7}, W_{da}^{7-7} and W_a^{7-7}). The depth of the arch (D_d^{1-7}, D_{da}^{1-7} и D_a^{1-7}) was determined as a distance from the frontal vestibular point to the line connecting the corresponding points of the second molars along the projection of the median palatal suture.

The arch form was determined through the arch index (the ratio between its depth and width). The mandibular dental arch form was defined as mesognathic in the cases where the dental arch index was 0.73±0.03, that of the dentoalveolar –0.85±0.05, and of the alveolar arch 0.83±0.05, regardless of the teeth size (macrodontia, microdontia or normal teeth size). For the brachygnathic form of the dental arch the index was below 0.7, the indices for the dentoalveolar and the alveolar arches being less than 0.80 and less than 0.78, respectively. In the event the dental arch index went beyond 0.76, that in the dentoalveolar arch exceeding 0.9 and in the alveolar arch exceeding 0.88, such form was classified as dolichognathic.

To estimate the size of the teeth we used the mean module of the molar crowns (half-sum of the first and second molar crowns modules). The crown module was calculated employing the A.A. Zubov method, taken as half-sum of the vestibular lingual and the mesial distal diameters of the tooth crown. The mean module of the molar crowns residing in the range of 10.6–11 mm was viewed as normal teeth size. A reduced value was typical of microdontia, while the value's increase was indicative of macrodontia in the permanent molars.

The outcomes suggest that in case of physiological occlusion of permanent teeth there were nine major types of dental arches to be found. Individuals with the mesognathic, brachygnathic, and dolichognathic arch forms revealed variants of microdontia, normal teeth size, and macrodontia of the permanent molars. There has also been an investigation into the parameters of the dental, the alveolar, and the dentoalveolar arches in patients with the above-mentioned forms of the dental arches.

The study has shown that regardless of the form of the dental arches and the teeth size, the matching index for the teeth size in relation to the frontal distal diagonal (the ratio between the sum of the mesial distal diameters of the seven teeth on one side to the length of the frontal distal diagonal) was stable, and for the dental arches it was 1.12±0.011, for the dentoalveolar arches – 1.08±0.01, while for the alveolar arches it was 1.14±0.01. This index is of high pragmatic value and allows determining whether or not the size of the teeth conforms to the size of the jaws, as well as it allows predicting a deficit or an excess of space for permanent teeth in the jaw bones. Mention to be made here that the dental arch length (which is the sum of the mesial distal diameters of 14 teeth) in case of normal teeth size in the permanent teeth averaged 107.0±4.0 mm. In case of macrodontia the dental arch length was over 112 mm, while for microdontia it was typical to have the dental arch length less than 103 mm.

We have studied the key parameters in the dental, the alveolar and the dentoalveolar arches also evaluating the interrelation between the major features. Table 1 contains the outcomes obtained through a study of the lower dental arches.

The outcomes have shown that under macrodontia of permanent teeth virtually all the measurements in the dental arches were significantly higher than in case of microdontia. The major indicator for the teeth size was the frontal distal diagonal (FDD_d^{1-7}).

During that, the key parameter for the dental arch form was the dental arch index, and the ratio between the depth of the dental arch (D_d^{1-7}) and the width between the second permanent molars in those with mesognathic dental arch was 0.72±0.03 for normal teeth size, 0.71±0.02 for macrodontia, and 0.71±0.02 under microdontia. The dental arch index for dolichognathic form was, on average, 0.81±0.05, while in case of brachygnathic form it averaged 0.67±0.03. Note to be made here of the ratio of the dental arch depth (D_d^{1-7}) to the depth of the anterior part of the arch (D_d^{1-3}), which in case of mesognathia was 5.75±0.3, for dolichognathia it was 4.61±0.3, while under brachygnathia it was 6.29±0.4, which indicates the variability of sagittal dimensions of the anterior part of the dental arch and is due to the teeth protrusion under dolichognathia and their retrusion in case of brachygnathia.

Table 2 contains the results of the lower alveolar arches measurements.

The results showed that the absolute values of the alveolar arches' parameters were significantly lower if compared to the dental ones. However, the comparative indicators revealed the same proportional relationships. The ratio of the depth of the alveolar arch (D_a^{1-7}) to the width between the second permanent molars (W_a^{7-7}) in those with the mesognathic alveolar arches was 0.82±0.02 for the normal teeth size, 0.83±0.03 for macrodontia, and 0.81±0.01 in case of microdontia

Table 1. *The key parameters of the lower dental arches in their shape variations*

Forms of the dental arches	Main measurements in dental arches (mm)				
	W_d^{7-7}	D_d^{1-7}	W_d^{3-3}	D_d^{1-3}	FDD_d^{1-7}
Mesognathic, normal teeth size	53.49±1.52	38.49±1.04	28.51±0.99	6.98±0.62	46.52±1.64
Mesognathic macrodontia	62.31±1.94	44.02±1.16	29.02±1.12	7.51±0.58	51.01±1.81
Mesognathic microdontia	51.68±1.41	36.51±1.07	24.03±0.89	6.22±0.54	43.79±1.82
Dolichognathic, normal teeth size	56.47±1.62	43.02±1.22	27.97±0.91	8.82±0.81	49.51±1.82
Dolichognathic macrodontia	55.51±1.94	49.04±1.86	29.01±1.11	10.03±1.35	52.02±1.75
Dolichognathic microdontia	51.49±1.42	40.53±1.47	27.49±1.08	9.96±1.14	45.29±1.87
Brachygnathic, normal teeth size	59.02±2.03	38.51±1.47	27.49±1.18	6.02±0.52	47.02±1.33
Brachygnathic macrodontia	60.04±2.12	40.03±1.28	26.51±1.16	6.61±0.87	47.18±1.97
Brachygnathic microdontia	54.01±1.84	35.49±1.12	25.78±0.84	5.53±0.46	44.02±1.27

Table 2. *The key parameters of the lower alveolar arches in their shape variations*

Forms of the lower arches	Main measurements in alveolar arches (mm)				
	W_a^{7-7}	D_a^{1-7}	W_a^{3-3}	D_a^{1-3}	FDD_a^{1-7}
Mesognathic, normal teeth size	46.52±2.12	38.02±1.45	27.71±1.23	6.48±0.79	45.51±1.28
Mesognathic macrodontia	53.48±2.13	44.12±1.47	28.03±1.07	8.51±0.96	50.49±1.97
Mesognathic microdontia	46.53±1.92	37.01±1.28	24.98±1.04	6.79±0.72	43.18±1.55
Dolichognathic, normal teeth size	49.51±2.37	44.97±1.28	27.39±1.08	9.49±0.89	48.48±1.54
Dolichognathic macrodontia	46.03±2.29	47.02±1.71	29.51±1.38	10.18±0.92	51.02±2.21
Dolichognathic microdontia	44.28±1.18	39.01±1.16	25.78±0.84	8.02±0.74	43.97±1.94
Brachygnathic, normal teeth size	50.96±1.59	38.02±1.14	27.97±1.09	5.51±0.43	45.97±1.94
Brachygnathic macrodontia	50.02±2.03	39.03±1.28	27.52±1.11	6.02±0.54	47.03±1.59
Brachygnathic microdontia	47.51±1.26	36.49±1.12	26.98±0.67	5.48±0.87	43.01±1.28

Table 3. *The key parameters of the lower dentoalveolar arches in their shape variations*

Forms of the lower arches	Main measurements in dentoalveolar arches (mm)				
	W_{da}^{7-7}	D_{da}^{1-7}	W_{da}^{3-3}	D_{da}^{1-3}	FDD_{da}^{1-7}
Mesognathic, normal teeth size	49.02±1.59	39.82±1.35	30.03±1.12	9.51±0.72	47.72±1.66
Mesognathic macrodontia	55.01±1.86	46.01±1.59	30.52±1.63	11.03±0.92	53.01±1.74
Mesognathic microdontia	47.98±1.44	39.29±1.42	27.48±1.02	8.79±0.85	45.52±1.36
Dolichognathic, normal teeth size	52.03±1.84	47.01±1.49	30.02±1.23	12.49±1.03	51.18±2.03
Dolichognathic macrodontia	48.49±1.65	50.49±1.93	31.04±1.13	14.01±1.24	54.12±1.95
Dolichognathic microdontia	46.01±1.88	41.98±1.33	29.01±1.11	10.52±1.03	46.53±1.24
Brachygnathic, normal teeth size	53.01±2.05	40.48±1.17	30.03±1.25	8.03±0.99	48.31±1.38
Brachygnathic macrodontia	53.49±1.91	42.51±1.77	31.01±1.12	9.01±0.97	49.28±1.93
Brachygnathic microdontia	49.02±1.54	39.02±1.81	28.99±1.12	8.19±0.88	45.52±1.51

of the permanent teeth. The ratio of the depth of the alveolar arch (D_a^{1-7}) to the depth of the anterior part of the arch (D_a^{1-3}) under mesognathia was 5.5±0.03, while for dolichognathia it was 4.7±0.4, and for brachygnathia — 6.7±0.04, coinciding with the similar dental arch indices.

Table 3 offers the study results regarding the dentoalveolar arches.

The dentoalveolar arch index under mesognathia averaged 0.82±0.03 and depended on the ratio of the sagittal and the transversal dimensions, while being virtually irrespective of the actual sizes of the teeth. The dentoalveolar arch index in case of the dolichognathic form was, on average, 0.95±0.04, while for the brachygnathic form it was 0.78±0.02. The fact that stands out here is the ratio of the depth of the dentoalveolar arch (D_d^{1-7}) to the depth of the anterior part of the arch (D_d^{1-3}), which under mesognathia was 4.3±0.2, under dolichognathia – 3.8±0.3, being equal to 4.8±0.03 for brachygnathia.

CONCLUSIONS

The major key parameter that determines the match between the teeth sizes and the dental arches' measurements is the frontal distal diagonal.

The proposed methods for the constructing and measuring of the dental arches based on the anatomical and topographical landmarks allow differentiating the three major types of dental arches: dental vestibular arch, alveolar lingual arch, and dentoalveolar arch.

The conventional dot placement will allow not only a comparative evaluation of the research outcomes at various stages of orthodontic treatment yet also will individualize the relationship between the parameters of the dental arches and the teeth size for each individual case.

Each of the dental arch forms proposed (dental vestibular arch, alveolar lingual arch, and dentoalveolar arch) reveal key parameters that may be used to determine the strategy for orthodontic treatment and to decide on the shape and size of metal dental arches when treating patients with the Edgewise technique.

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