

ORIGINAL ARTICLE

Comparative analysis of the influence of the shapes and dimensions of dental arches on the morphotopogeometric characteristics of the facial area

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ABSTRACT

Aim: The aim of the article is a comparative analysis of the main aspects of existing medical and diagnostic measures in patients with abnormal types of occlusal relationships and methods of mathematical and graphic reproduction of the shape of the dental arches, taking into account the individual characteristics of the maxillofacial area.

Materials and Methods: The search for relevant publications related to the objective topic was carried out through scientific databases: Scopus, PubMed, BVS and Scielo.

Conclusions: The analysis of regression models of the reproduction of individual characteristics of the dental arch of the jaws will avoid errors that occur when comparing the actual sizes with their statistical norm, which will allow to correctly determine the proportionality and ratio of different departments of the dental and jaw system, the necessary amount of orthodontic measures in the treatment of anomalies of the dental arches.

KEY WORDS: dental arch anomalies, orthodontic treatment, mathematical and graphic modeling, arch shape, facial types

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INTRODUCTION

In clinical orthodontics, for many decades and to this day, issues regarding the shape of dental arches and the peculiarities of their sizes remain debatable. Numerous works of researchers were aimed at finding the ideal shape of the dental arch, which provides the functional and morphological optimum of the maxillofacial region [1, 2].

Questions related to the determination of linear and angular parameters of dental arches, taking into account the individual characteristics of the maxillofacial system, remain problematic and controversial. Questions regarding variants of the physiological functional norm of the masticatory apparatus associated with the peculiarities of the morphological structure of the dental arches and their connection with the facial and cerebral parts of the head are discussed [3].

Recently, in addition to the generally accepted measurements of the maxillofacial arches in the transverse and sagittal directions, methods of biometric analysis of the arches in the diagonal direction have become widespread. It is proposed to evaluate the specified parameter both in the front segment of the arch and in general when examining the full arch.

Specialist studies published in domestic and foreign sources are dedicated to the individualization of the main biometric indicators of the dental arches and their relationship with the parameters of the maxillofacial area.

At present, the influence of individual characteristics of the maxillofacial system and their proportionality to the dental arches on the stability of the results of treatment in the clinic of orthodontics and prosthetic dentistry, in particular, in the treatment of abnormal forms of dental arches, remains insufficiently studied. Little attention has been paid to the research of the front segment of the dental arches, taking into account the geometry of the circle and the calculation of the main properties, in relation to stable values, which include the medial-distal dimensions of the crowns of the front teeth. Despite the fact that many modern methods of graphic reproduction of dental arches have been proposed, there is practically no information about recommendations for their application, taking into account the types of dental arches [4].

It is necessary to improve the methods of graphic construction of arches in the case of anomalies of their shape and size, taking into account the individual characteristics of the projected dental arches. The analysis of numerous studies in this direction aims to find new solutions to this problem, dedicated to the selection of the main predicted parameters of the maxillofacial arches in patients with anomalies and deformations of the maxillofacial region.

AIM

The purpose of the article is a comparative analysis of the main aspects of existing medical and diagnostic measures in patients with abnormal types of occlusal relationships and methods of mathematical and graphic reproduction of the shape of the dental arches, taking into account the individual characteristics of the maxillofacial region.

MATERIALS AND METHODS

The search for relevant publications related to the objective topic was carried out through scientific databases: Scopus, PubMed, BVS and Scielo using the following keywords: anomalies of dental arches, orthodontic treatment, mathematical and graphic modeling, arch shape, facial types. The review included original articles, studies and official recommendations of the medical association. All collected articles were processed according to the principles of content analysis with further systematization and categorization of the received data in CADIMA software.

REVIEW AND DISCUSSION

The nature of the ratio of anatomical structures of the head determines not only the peculiarities of the functioning of the maxillofacial system, but also creates a sense of harmony and aesthetic perception of the human face [3-5]. When studying the possibilities of correction of maxillofacial deformations and the profile of soft tissues of the face for further orthodontic or surgical treatment or facial contour plastic, it is very important for the doctor, in addition to his subjective vision and the wishes of the patient, to have clearer values of metric indicators and their individual variations .

In an attempt to objectify the understanding of harmony, function and aesthetics of craniofacial structures, various methods of cephalogram analysis with corresponding normative diagnostic values have been proposed by researchers studying individuals with normal occlusion and balanced faces Schwarz A. M., McNamara J., Downs W. B., Holdway R. A., Schmuth G. P. F., Steiner C. C., Tweed C. H. and others. These methods form the foundation of modern anthropometric studies aimed at studying the ethnic diversity of human features and a deeper understanding of the interaction and relationships of various anatomical structures of the face. But some studies indicate that the values themselves, 26, were proposed as "universal" or "normal" are often incorrect in diagnostic and treatment planning in patients of different ethnic and racial groups [4, 6, 7].

In orthodontics for centuries and to this day, questions regarding the shape of dental arches and the features of their sizes remain controversial. Numerous works by researchers have been aimed at finding the ideal shape of the dental arch, providing a functional and morphological optimum of the maxillofacial area [5, 7, 8].

To this day, scientific research continues aimed at individualizing the shapes of the dentofacial arches, taking into account the size of the patient's head and face. The variety of physiological types of arches that determine the normal functional state of the masticatory organ significantly complicates the search and interpretation of the "ideal" shape of the dentofacial arch. In this regard, experts have proposed optimal forms of dental arches, taking into account the characteristics of the morphological structure of the maxillofacial region [9].

Experts recommend evaluating the shapes of dental arches using mathematical forms, highlighting spline curves, beta functions, etc. [8, 9]. Often, when characterizing the shapes of dental arches, one comes across terms that define elliptical or parabolic curves, conical sections, and chain curves [10]. The differences between the gnathic and dental types of dental arches determine the location of the anterior teeth [7, 11, 12]. The value of the interincisal angle in people with different types of arches is shown [12]. The anterior section of the dental arch is given special attention, since its parameters in most cases are the basis for calculating the radius of the circle for their location, which we find in the works of Hauley [4, 6, 11, 12].

Amendments have been made to the radius calculations taking into account the geometry of the circle and the proportionality of the circumference to the number π (3.14). Based on this principle, a substantiation was made for the calculation of the gnathic type of arch based on the width of the anterior segment of the arch. It was shown that with physiological types of arches, in particular with mesognathia, the difference between the calculated and actual width of the arch did not exceed 2 mm. At the same time, in people with brachygnathia, an increase in the parameter was considered normal, and in dolichognathia, its decrease was considered normal, which was reflected in the shape of the dental arches [6, 8, 10-14].

Researchers have noted the dependence of the depth of the anterior segment of the dental arch on the intercanine distance in people with different types of arches [12, 15].

To determine the intercanine distance, index values have been proposed that take into account whether the arch belongs to a certain gnathic and dental variant [7, 8, 10, 11, 14, 15].

Recently, information has appeared about the influence of the main types of dental arches on the morphological features of the human facial area. The influence of the location of the anterior teeth on the shape of the bone elements of the temporomandibular joints has been shown [10, 11, 14].

A correlation has been shown between the sizes of the articular and dental mandibular triangle in people with physiological occlusal relationships [8]. Methods for constructing these triangles are presented in detail and their diagnostic value is shown [12, 14]. The high percentage of prevalence of anomalies in the shape and size of dental arches and the variety of variants of the clinical picture of pathology still remain one of the most serious problems of clinical orthodontics in various regions of the country and abroad [9, 11, 15, 16].

In children living in Iran, according to data presented by Akbari M. (2016), malocclusions with a neutral position of the first permanent molars accounted for 54.6%, and more often in girls than in boys [14, 15].

It was noted that in the east of the country the prevalence of pathological occlusion reached 99.7% [17].

In Saudi Arabia, when examining adolescents, occlusion pathology was identified in 90% of those examined. Sexual dimorphism was also noted and it was shown that in females the prevalence rates were higher than in the male population of the country [6, 11, 14, 16].

When analyzing the results of a survey of 3017 school-age children living in Italy, it was shown that 75.8% of children had anomalies of occlusal relationships during the period of mixed dentition [15, 17, 18].

In Brazilian residents, the prevalence of anomalies was observed in 81.4% of residents of various social groups and was shown to depend on economic living conditions [11, 12, 18, 19]. A similar situation was observed among residents of China and India. As noted by many clinicians, in almost all occlusion anomalies, the dental arches are changed and their shape is so variable that it is difficult to classify them according to any criteria [19].

The analysis of regression models of reproduction of individual characteristics of the dental arches of the upper and lower jaws in boys and girls of Ukraine with an orthognathic bite depending on odontometric and cephalometric indicators without taking into account and taking into account the craniotype was developed and carried out. For the practical use of the obtained modeling results, a method of reproducing the correct form of the dental arch is proposed, using the DentaForm computer program, which will allow the dentist to quickly and qualitatively build the form of the dental arch necessary for the patient, conduct an objective assessment of the treatment of the pathology, reduce the treatment time and reduce the number of recurrences of the disease [20-22].

The variety of methods and philosophies of treatment, the absence of single clear criteria for the quality of orthodontic treatment lead to the occurrence of a significant number of relapses, which can reach the level of 20%. The urgency of solving the problem of relapses is due to the fact that only a fifth of patients retain the results of completed orthodontic treatment. This is due to the peculiarities of the anatomy and physiology of the maxillofacial apparatus, the connection of the maxillofacial system with other physiological systems [23, 24]. Among the various reasons described in the literature that cause relapses, important importance is attached to the creation of functional occlusion and the reproduction of normal individual indicators of the spatial arrangement of teeth, forms of dental arches and their ratio, which is a prerequisite for effective orthodontic treatment [25].

Diagnostics of abnormalities in the shape and size of the dental arches does not cause visual difficulties for clinicians and is based on numerous methods based on odontometric signs and relationships with the parameters of the face and, in particular, of the ego gnathic department [12, 18].

The concept of the variability of the form and basic parameters of dental arches is based on the morphological principle of the relationship with the craniofacial complex [19, 21].

It is recommended to use computer technology and X-ray examination when diagnosing anomalies of the maxillofacial region. The main attention, of course, should be paid to craniometry and determining the correspondence of the dimensions of the face to the parameters of dental arches and teeth [21, 24, 26]. In clinical orthodontics, it is recommended to assess whether a face belongs to a certain type, taking into account linear indicators and calculating index values. The facial index is determined by the ratio of the vertical size (height) of the face to its width between the cheekbones and is estimated as a percentage equivalent. The determination of the face profile is based on the indicators of the facial angle, formed by the Frankfurt horizontal and the nasolabial line. I single out three main profiles of the child and characterize it as ortho-, meso- and prognathic [18, 19, 24].

In clinical orthodontics, classifications of face types have become widespread, in which the definition of the profile is based on the position of the subnasal or chin point relative to vertical lines. When the subnasal point is located near the Dreyfus line, it is typical for mesofrontal faces. Moving the specified point forward is characteristic of the transfrontal type of face, and the backward displacement is characteristic of the cisfrontal type. Displacement of the chin point in the sagittal direction characterizes the profile of the face as slanted to the back or to the front [3, 17].

Abnormalities of occlusal relationships in the sagittal direction are reflected in the facial profile and are often recognized as a diagnostic criterion of pathology [26]. However, the proposed classifications of typological variants of the face may not always be useful for determining the correspondence of facial parameters with biometric indicators of dental arches, since even with physiological occlusion, the specified types of arches are found [27].

In each variation, taking into account the dental index, normo-, macro- and microdont types are distinguished [11, 14, 17, 26]. Observations and research by specialists aimed at studying the proportionality of dental arches with typological variants of the facial area deserve attention. At the same time, the calculation of dental indicators and gnathic indices for maxillofacial arches, which are based on diagonal and transverse indicators [26, 28], is proposed.

Methods of X-ray diagnosis of dental and jaw anomalies are presented in detail [28]. The diagnostic possibilities of combining various radiographs on a computer are shown, and the effectiveness of such structures is shown when analyzing the proportions of dental arches and morphological elements of the facial part of the head [23, 27]. Currently, the dependence of the diagonal sizes of the dental arches, in particular the frontal-molar diagonal, with the diagonal of the face, which is recommended to be measured from the tragion point (t) to the subnasal point subnasal (sn), has been determined. Moreover, this relationship depends on the size of the teeth to a greater extent than on the profile of the face [27, 28].

Researchers cite values (from 123 mm to 130 mm) characterizing the normodontic face type. At the same time, they refer to the coefficients of correspondence of the diagonal sizes of the dental arches with the diagonal of the face. The obtained conclusions require correction and argumentation, which was one of the tasks of this study [28]. Computer methods of research and modeling of pathological conditions are proposed to determine rational treatment methods [17, 18, 22, 26]. However, it is necessary to improve the methods of research in the maxillofacial region. Anthropologists, dentists and other specialists pay attention to the features of the shape and size of dental arches [24].

Determining the characteristics of the size of teeth, dental arches, dentofacial segments and the maxillofacial region as a whole has applied and clinical significance, as evidenced by literature sources [13, 14, 16, 17, 19, 21].

Odontometry forms the basis of all diagnostic measures in an orthodontic clinic. At the same time, research by specialists is aimed at assessing the proportionality of the teeth of the upper and lower jaws with the calculation of dental and interdental indicators [25, 28-30].

However, in most cases, the authors of scientific publications are inclined to the opinion that the size of teeth in physiological occlusion, as a rule, is determined by the characteristics of the size of the maxillofacial area, regardless of the race and/or gender of the individual [25, 29] . Odontometric indicators determine whether the dental arch belongs to a certain dental type, among which the most common are maco-, micro- and normodont variants [29, 30].

The improvement of diagnostic and treatment methods for deformations and anomalies of the dental arches deserves attention [4, 12, 14, 23, 26, 29]. The generally accepted methods for determining the width of the dental arches are the Pont and Linder-Harth methods, based on the ratio of the sum of the width of the crowns of the 4 upper incisors to the premolar index (80 and 85) and the molar index (64 and 65) [29, 31]. The fact that different index numbers are used to assess calculated indicators of the same values is cause for concern, and difficulties often arise when interpreting the results of the study [32,].

At the same time, it has been established that for mesognathic types of dental arches, both proposed methods can be used with a high probability. As the results of the study of brachygnathic dental arches showed, the index values calculated using the Linder-Harth method were significantly less than the actual values, which determined the inappropriateness of using this method when analyzing the type of dental arches under study, both mandibular and maxillary [32].

To characterize the dental arches of physiological occlusion, nine forms have been identified, each of which has features of odontometric indicators and linear dimensions of the arches in various directions, including diagonal [30, 31]. The basis for determining the gnathic types of dental arches is the ratio of sagittal to transversal dimensions, which determines the index of the arches [12, 18-20, 26, 30].

The construction of a dental arch using the geometric-graphic method has attracted the attention of specialists for many decades [11, 13]. The proposed graphic reproduction of the dental arch using the Howley-Herber-Herbst method has become firmly established in educational and specialized literature and has become an attribute for diagnosing occlusion anomalies [2, 4, 6, 18, 26, 27].

Recently, clinicians have been paying attention to some errors in construction, which lead to a discrepancy between the true parameters of the dental arches and their graphic construction. However, these observations were valid for dental arches whose intercanine width was twice the anterior arch depth [30, 32].

Particular attention is drawn to the graphic construction of the dental arch, based on the laws of the geometry of the circle. The arc radius is determined by calculating the central angle. Determination of the depth and width of the anterior segment is carried out using the Huygens formula, where the sum of the width of the crowns of six anterior teeth was taken as the length of the arc [29, 31].

This method made it possible to calculate latitude indicators in the canine area and sagittal (depth) of the anterior segment of the dental arch with an abnormal arch shape, taking into account odontometric indicators. The constructed diagram contained landmarks that made it possible to compare an arch with an abnormal shape using points located on the second molars. Clinical cases are presented showing the effectiveness of the method in the diagnosis and treatment of pathology [31].

The opinion of specialists is worthy of attention, who believe that with equal tooth sizes, the shape of the anterior part of the dental arch can be different [22, 29, 30]. In this regard, it has been proposed to use two interdependent quantities, such as the width and depth of the anterior dental arch, limited by permanent canines [28, 29].

A method has been developed for constructing an arch, where a value equal to the difference between the width and depth of the dental arch to the level of the canines was used as the diameter of the circle. However, this study was conducted in people with physiological occlusion of permanent teeth [29]. If there are anomalies in the shape of the dental arches, it is difficult to more (or less) accurately determine the indicated values. In addition, even with physiological occlusion, there are many varieties of shape and size of dental arches [8, 15, 17, 19, 22, 23]. Taking into account the above, we came to the conclusion that the graphic construction of the dental arch using the Howley-Herber-Herbst method requires some clarification. This postulate is based on the opinion of researchers who proposed various options for the shape and size of dental arches, taking into account gnathic (meso-, brachy- and dolichognathia) and dental (normo-, macro- and microdontism) types [12, 30, 32].

Experts have shown the possibility of using graphical constructions of dental arches for the period of occlusion of primary teeth and given recommendations for their use in a pediatric dentistry clinic [10, 11].

With the development of computer modeling methods and mathematical analysis methods, graphical methods for constructing dental arches are becoming relevant and deserve the attention of clinicians [7, 9, 11, 32].

At the end of the last century, the Stanley Braun method, designated by the author as the Beta-function, firmly entered the specialized literature at the end of the last century. Mathematical calculations and construction of the arc were carried out by the author using coordinates (x-, y- and z). The construction was carried out using computer programs [10, 13, 33].

Dostalova T. and co-authors analyzed 792 models obtained during different periods of orthodontic treatment and compared the resulting series. The authors proposed computer monitoring of the image of dental arches in the dynamics of treatment and concluded that the proposed

computer diagnostic methods are reliable [11, 19, 31-33].

Modern OrthoCAD technologies, according to experts, are equivalent to 3D modeling of dental arches and are recommended as a standard for clinical research [17, 21, 27]. Most methods for studying dental arches are cumbersome and require numerous dental measurements in a comparative aspect with linear parameters. Therefore, the issues of rapid diagnostics to determine anomalies of the dental arches remain relevant. For anomalies of the dental system, the need for treatment by an orthodontist has been noted by many authors. The principle of orthodontic treatment comes down to achieving an optimal individual occlusal concept [11, 14, 16, 21, 29-31].

Particular attention is paid to occlusal control at all stages of treatment. The features of complex treatment are shown and its effectiveness is presented in people with various types of anomalies of occlusal relationships, which are often combined with dental defects of varying lengths [28, 30, 32].

Of particular importance in clinical orthodontics is the preventive focus on preventing the occurrence of relapses after orthodontic treatment, as evidenced by the data of specialists who have been studying the features of the retention and post-retention periods of treatment for a decade [24, 28].

According to the authors, the main cause of relapses is an aggressive change in the size of the dental arches during orthodontic treatment with mechanical devices. Moreover, the authors did not find significant differences when using extraction or non-extraction methods of treatment. According to the authors, even minimal changes in size were not a guarantee of stability during the retention period. In particular, experts paid attention to changes in the intercanine distance, where the measuring points were located on the tearing tubercles of the canines [10, 13, 15, 22, 29, 33, 34].

The widespread introduction of edgewise technology into clinical orthodontics has made it possible to change almost all types of abnormal forms of dental arches. At the same time, the work of most specialists is aimed at the correct choice of braces, the size of metal arches and the possibility of their preformation, taking into account the individual characteristics of the individual [30-35]. For this purpose, namely to select the sizes of metal arcs, Lloyd's discrete algorithm was proposed [33, 35]. The 4 types of arch patterns proposed by the author have been used in clinical practice and their effectiveness has been shown. Recently, trainers and positioners of industrial and individual manufacture have proven themselves well, and the possibilities of modeling the predicted shapes of dental arches when using them have been shown [29, 30, 32, 36, 38].

When analyzing the literature sources devoted to the study of dental arches, both normally and in pathology, it was found that the research topic is relevant, practically important, and further research is required aimed at increasing the effectiveness of treatment and preventive measures in clinical orthodontics. Research aimed at substantiating the effectiveness of graphic reproductions in the diagnosis and treatment of dental arch anomalies is worthy of attention [33, 35, 37].

The discussion about the interdependence of the size, shape, position of the dental arches and odontometric characteristics, morphology of the facial and cerebral skull in people with an orthognathic bite has gained special importance in recent years. This is due, first of all, to the introduction of new methods of diagnosis and treatment with the use of fixed orthodontic equipment, intended for the correction of various types of anomalies of the dento-maxillofacial system [33, 34, 38].

Most of the studies conducted on the morpho-geometric regularities of the formation of the dental arches of the upper and lower jaws relate to the childhood, adolescent, and mature stages of human ontogenesis. There is a certain lack of knowledge about the variant anatomy of this area in young people. This period of life is important because the upper and lower jaws reach their maximum size, the permanent bite is finally formed, which is associated with the eruption of the third permanent molars.

Considering that numerous studies by clinicians and scientists around the world have proven the need to adapt the regulatory framework of classical methods of cephalometric measurements with the help of radiographic research methods for use in different ethnic groups of the population, it is relevant and important both from a theoretical point of view for human anatomy and from a practical point of view for dentists, it is the establishment of anthropometric and odontological regularities of the location of the maxillofacial structures of the facial skull in young men and women of Ukraine and the development of a method of diagnosis and orthodontic correction of maxillofacial deformations.

CONCLUSIONS

Thus, it can be concluded that modern dentistry is interested in researching and finding individual norms and correlational dependences of dental arch parameters and cephalometric indicators, taking into account gender and ethnicity, with the aim of providing maximum individual orthodontic care to the patient, which completely coincides with the direction of modern medicine as a whole all over the world

Conducting regulated screening studies is most successful in assessing the individual and craniotypological range of variability of anatomical features in conditions of normal bite development. The available clinical guidelines for computed tomography visualization contain very little information about the morphometric parameters of the dental arches and teeth, often limited to the average values of the signs.

Taking into account the dimensions of dental arches in a proportionally hierarchical relationship with odonto-cephalometric parameters, which are obtained from the natural three-dimensional arrangement of all structures in a living person, is relevant in the clinic of gnathology, orthodontics, maxillofacial surgery, as well as in forensic medical practice for identification persons

The diagnosis of orthodontic pathologies is based on a large number of different signs, in connection with which, the question arises about the use of mathematical methods for data processing, which can significantly speed up the process of making a diagnosis and choosing treatment tactics. From the standpoint of medical anthropology, it is important to establish internal relationships between any

components, including cephalometric and odontometric ones. Mathematical modeling, namely the development and analysis of regression models of the reproduction of individual characteristics of the dental arch of the upper and lower jaws will avoid errors that occur when comparing the actual sizes with their statistical norm, which, in turn, makes it possible to correctly determine the proportionality and ratio of different departments of the dentition system and skull, the required amount of orthodontic measures in the treatment of anomalies of the dental arches.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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