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REGRESSION MODELS OF THE DIMENSIONS OF THE DENTAL ARCH SHAPE IN GIRLS WITH A PHYSIOLOGICAL BITE AND A VERY WIDE FACIAL TYPE DEPENDING ON THE FEATURES OF TELERONTGENOMETRIC INDICATORS BY THE RICKETTS METHOD AND COMPUTED TOMOGRAPHIC DIMENSIONS OF THE TEETH

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In Ukrainian girls with physiological occlusion and a very wide face type, based on the features of teleradiometric indicators according to the Ricketts method and computed tomography dimensions of the teeth, all 18 possible reliable highly informative models (R^2= from 0.626 to 0.913, p<0.001 in all cases) of linear dimensions necessary for constructing the correct shape of the dental arch were constructed. The models most often include teleradiometric indicators according to the Ricketts method (34.71 %), the width of the tooth crown in the mesio-distal and vestibulo-oral directions (24.79 % and 13.22 %, respectively), upper and lower incisors (15.70 % and 12.40 %, respectively).

Key words: dentistry, regression models, dental arches, teleradiometry, tooth sizes, girls, face type, physiological bite.

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РЕГРЕСІЙНІ МОДЕЛІ РОЗМІРІВ ФОРМИ ЗУБНОЇ ДУГИ У ДІВЧАТ ІЗ ФІЗІОЛОГІЧНИМ ПРИКУСОМ І ДУЖЕ ШИРОКИМ ТИПОМ ОБЛИЧЧЯ В ЗАЛЕЖНОСТІ ВІД ОСОБЛИВОСТЕЙ ТЕЛЕРЕНТГЕНОМЕТРИЧНИХ ПОКАЗНИКІВ ЗА МЕТОДОМ RICKETTS І КОМП'ЮТЕРНО-ТОМОГРАФІЧНИХ РОЗМІРІВ ЗУБІВ

В українських дівчат із фізіологічним прикусом і дуже широким типом обличчя на основі особливостей телерентгенометричних показників за методом Ricketts і комп'ютерно-томографічних розмірів зубів побудовані усі 18 можливих достовірних високоінформативних моделей (R^2= від 0,626 до 0,913, p<0,001 в усіх випадках) лінійних розмірів необхідних для побудови коректної форми зубної дуги. До моделей найбільш часто входять телерентгенометричні показники за методом Ricketts (34,71 %), ширина коронки зуба у мезіо-дистальному та вестибуло-оральному напрямках (відповідно 24,79 % і 13,22 %), верхні та нижні різці (відповідно 15,70 % і 12,40 %).

Ключові слова: стоматологія, регресійні моделі, зубні дуги, телерентгенометрія, розміри зубів, дівчата, тип обличчя, фізіологічний прикус.

The study is a fragment of the research project "Development and improvement of individual methods of diagnosis, treatment and prevention of dental and jaw anomalies, caries and its complications in children and adolescents", state registration No. 0120U105689.

Over the past decades, the attention of researchers and practitioners has increasingly focused on the study of morphometric characteristics of the dentofacial system, which have prognostic significance for the diagnosis and treatment of malocclusion. In particular, the problem of establishing a relationship between the morphology of the jaws, the shape of the dental arch, the size of the teeth and teleradiometric parameters of the face remains relevant. In this context, it is also important to study the features of dentofacial development in individuals with certain anthropological features, in particular in patients with a very wide facial type and physiological occlusion. According to a retrospective study in France conducted among orthodontic patients, the frequency of detection of dentofacial anomalies was 36.4 %. The most common were microdentia (11.1 %) and hypodontia (9.6 %) [4]. This suggests that more than a third of patients seeking orthodontic care in developed countries have diagnosed dental anomalies that directly affect the shape of the dental arch and the nature of the occlusion.

In Saudi Arabia, a high level of specific dental anomalies was found among patients with congenital clefts of the upper lip and palate: the frequency of lateral incisor hypodontia was 66 %, and supernumerary teeth was 28 %. Such indicators indicate a significant contribution of congenital factors to the formation of pathologies of the dento-maxillary system [2].

Regarding Asian countries, in particular South Korea, the study found that individuals with hypodontia often have concomitant anomalies, including mesiocclusion, conical teeth, microdentia, and supernumerary teeth. Thus, 42.5 % of individuals with missing permanent teeth had at least one concomitant anomaly, confirming the polyetiological nature of developmental disorders of the dento-maxillary apparatus [6].

Mexican scientists found that the frequency of retention of upper canines in a sample of patients was 6.04 %, and 34 % of these cases were accompanied by other anomalies, among which hypodontia (11.7 %) and the presence of excess teeth (6.4 %) dominated [9].

Interestingly, even within the same anatomical zone – the upper and lower jaws – different patterns of distribution of dento-maxillary anomalies are observed. Thus, one study indicated that hypodontia occurs more often on the lower jaw – 59.4 %, compared to 40.6 % of cases on the upper. Moreover, the most frequently absent premolars are: the second lower premolars – in 24.4 % of cases, the first lower – in 17.5 % [1].

Thus, the accumulated statistical data from different countries of the world indicate a high prevalence and significant variability of anomalies of the dentofacial system. The study of their patterns in the context of teleradiometric indicators, taking into account the computed tomography characteristics of the teeth, is a promising direction of scientific research. The analysis of this problem in individuals with a very wide facial type, where the prediction of the shape of the dental arch is of crucial importance for the effectiveness of orthodontic intervention, is of particular importance.

The purpose of the study was to construct and analyze regression models of the dimensions necessary to construct the correct shape of the dental arch in Ukrainian girls with a physiological bite and a very wide facial type, depending on the characteristics of teleradiometric indicators according to the Ricketts method and computed tomography dimensions of the teeth.

Materials and methods. Teleradiographic and computed tomography examination of 30 Ukrainian girls (aged 16 to 20) with physiological occlusion and very wide face type according to Garson was performed using dental cone-beam tomograph Veraviewepocs 3D Morita (Japan) and Planmeca ProMax 3D Mid (Finland) in the software shell i-Dixel One Volume Viewer (Ver.1.5.0) J Morita Mfg. Cor and Planmeca Romexis Viewer (ver. 3.8.3.R 15.12.14) Planmeca OY. In addition to the teleradiographic images obtained in the standard way, teleradiographic images with points marked on 3D objects, created in the 3D Slicer v5.4.0 software, were used. Further analysis and processing of teleradiograms were carried out in the licensed software OnyxCeph³™, version 3DPro, from Image Instruments GmbH (Germany).

All examinations were conducted on the basis of the principle of voluntary informed consent. The Bioethics Committee of the National Pirogov Memorial Medical University, Vinnytsya (protocol No. 7 dated 8.11.2022) established that the conducted studies do not contradict the basic bioethical norms of the Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine (1977), the relevant provisions of the WHO and the laws of Ukraine.

The Ricketts R. M. method was used to analyze lateral teleradiograms [13]. This method was used to determine the size of the distances (mm) 6u-6l, Overjet, Overbite, 1l-OcP, 3u-3l, A-NPog, 6u-PTV, 1l-APog, 1u-APog, Xi-OcP, Li-NsPog', ANS-sto, sto-OcP, N-CC, Go-CF, P-PTV, Xi-Pm and the size of the angles (°) Max1-Mand1, ANS-Xi-PM, Mand1-APog, Max1-APog, NPog-POr, NBa-PtG, MeSgo-NPog, MeSgo-POr, POr-NA, N-CF-A, POr-SpP, POr-NBa, POr-CFXi, DC-Xi-Pm.

The following computed tomography tooth sizes were also determined in the mesio-distal (Md) and vestibulo-oral (Vo) directions [5]: width (MdK, VoK) and height (MdLK, VoLK) of the tooth crown, width of the dentine enamel boundary (MdC, VoC), root length (MdLR, VoLR) and tooth length (MdLD). Taking into account previous studies by Marchenko A. V. et al. [12], we used the average values of the corresponding teeth on the upper and lower jaws: 11 or 41 – upper or lower central incisors, 12 or 42 – upper or lower lateral incisors, 13 or 43 – upper or lower canines, 14 or 44 – upper or lower first premolars, 15 or 45 – upper or lower second premolars, 16 or 46 – upper or lower first molars.

In the licensed statistical package "Statistica 6.0", using the stepwise regression analysis method, the following parameters necessary for constructing the correct shape of the dental arch were simulated [5]: in the transverse plane – the distances between the canine eruption cusps on the lower (33_43Bugr) and upper (13_23Bugr) jaws, the vestibular medial cusps of the first molars (VestBM) of the upper jaw, the premolar (PonPr) and molar (PonM) points behind Pon, on the upper jaw the distances between the canine root tips (13_23Apx), between the tips of the medial (napx_6), distal (dapx_6) and palatal (mapex_6) roots of the first large canines, and on the lower jaw the distances between the canine root tips (33_43Apx), between the tips of the medial (mapx_46) and distal (dapx_46) first large canines; *in the sagittal plane* – the distances between the incisal point and the midpoints of the canine (DL_C), premolar (DL_F) and molar (DL_S) lines; *in the vertical plane* – the distances of the occlusal plane from the palate at the level of the canine (GL_1), premolar (GL_2) and molar (GL_3) lines.

Results of the study and their discussion. Regression models of linear dimensions necessary for constructing the correct shape of the dental arch, depending on the features of teleradiometric indicators according to the Ricketts method and computed tomography dimensions of the teeth, constructed in

Ukrainian girls with a physiological bite and a very wide facial type, have the form of the following linear equations:

– *distance value 33_43Bugr*=30.87 + 0.318×DC-Xi-Pm + 0.431×MeSgo-POr - 0.503×ANS-sto - 0.336×NPog-POr + 0.180×N-CC + 0.451×1l-APog + 0.422×VoLR12 (R^2=0.721, $F_{(7.22)}$=8.14, p<0.001, Std.Error of estimate=1.649);

– *distance value 13_23Bugr*=50.90 + 0.412×MdLD12 - 0.313×POr-NA - 0.394×ANS-sto + 0.191×Xi-Pm + 0.475×VoLK43 - 0.082×N-CC (R^2=0.626, $F_{(6.23)}$=6.42, p<0.001, Std.Error of estimate=0.842);

– *distance value VestBM*=51.59 + 1.838×VoK16 - 3.093×MdK44 - 0.486×MdLD45 + 1.107×MdLK42 - 0.150×ANS-Xi-PM - 1.136×MdK13 + 0.169×POr-NA + 0.860×MdC13 (R^2=0.835, $F_{(8.21)}$=13.29, p<0.001, Std.Error of estimate=0.766);

– *distance value PonPr*=12.74 + 1.755×MdLK42 + 0.497×VoLK11 + 0.317×POr-SpP - 1.102×N-CC + 0.309×POr-NBa + 0.455×VoLK41 (R^2=0.733, $F_{(6.23)}$=10.53, p<0.001, Std.Error of estimate=0.987);

– *distance value PonM*=-13.07 + 0.300×MeSgo-POr - 0.150×ANS-Xi-PM + 0.604×N-CF-A + 0.967×MdLD43 - 1.609×VoK44 + 1.821×MdK41 + 0.845×VoK15 (R^2=0.727, $F_{(7.22)}$=8.35, p<0.001, Std.Error of estimate=1.103);

– *distance value 13_23Apx*=16.11 - 3.455×MdK43 + 0.429×MdLD11 + 0.038×Mand1-APog + 0.392×POr-NBa + 1.254×MdK11 + 1.004×VoK16 - 1.239×VoK12 (R^2=0.802, $F_{(7.22)}$=12.72, p<0.001, Std.Error of estimate=0.956);

– *distance value napx_6*=-2.980 + 2.701×MdLK11 - 1.218×VoLR12 + 1.188×VoLK13 - 1.648×MdC41 + 1.143×Overjet + 2.075×MdK11 + 0.209×6u-PTV (R^2=0.864, $F_{(7.22)}$=20.03, p<0.001, Std.Error of estimate=1.228);

– *distance value dapx_6*=23.12 - 3.396×3u-3l + 2.406×MdK15 + 0.175×Max1-Mand1 + 1.381×MdLD43 - 0.389×NBa-PtG + 1.256×1l-OcP - 1.042×6u-6l (R^2=0.771, $F_{(7.22)}$=10.56, p<0.001, Std.Error of estimate=2.315);

– *distance value mapex_6*=11.47 + 1.502×MdK45 + 3.705×MdK11 + 0.520×ANS-sto - 1.618×MdK16 + 1.350×VoK15 - 0.530×MdLR13 (R^2=0.748, $F_{(6.23)}$=11.37, p<0.001, Std.Error of estimate=1.630);

– *distance value 33_43Apx*=58.51 - 0.810×POr-NA + 0.681×MdLR41 + 3.416×VoK43 - 2.583×MdK45 + 2.224×MdK46 + 2.023×MdK41 - 1.893×VoK13 (R^2=0.835, $F_{(7.22)}$=15.95, p<0.001, Std.Error of estimate=1.516);

– *distance value mapx_46*=53.44 - 0.687×VoLK11 - 0.541×1u-APog - 1.068×Overbite - 1.344×VoK44 + 2.267×VoK16 - 0.183×P-PTV - 1.430×VoK45 (R^2=0.913, $F_{(7.21)}$=31.32, p<0.001, Std.Error of estimate=0.857);

– *distance value dapx_46*=60.30 - 0.246×Max1-APog - 0.976×VoLK11 + 2.788×MdK41 - 0.341×MdLR41 - 0.217×P-PTV - 0.850×VoK45 (R^2=0.834, $F_{(6.22)}$=18.49, p<0.001, Std.Error of estimate=1.176);

– *distance value DL_C*=-0.053 + 1.945×MdK11 - 1.747×MdK15 + 1.533×MdK42 + 0.921×MdC13 - 0.197×VoLR12 - 0.928×MdK12 + 0.146×sto-OcP (R^2=0.826, $F_{(7.22)}$=14.87, p<0.001, Std.Error of estimate=0.449);

– *distance value DL_F*=-1.118 + 2.125×MdK11 + 0.964×MdK16 - 1.035×MdK15 - 0.280×MdLD15 + 0.151×Li-NsPog' + 0.537×VoK42 (R^2=0.853, $F_{(6.23)}$=22.26, p<0.001, Std.Error of estimate=0.487);

– *distance value DL_S*=2.770 + 1.305×MdK11 + 1.624×MdK16 + 0.380×1u-APog + 0.999×VoK14 - 0.675×VoK45 - 0.636×VoC13 (R^2=0.889, $F_{(6.23)}$=30.63, p<0.001, Std.Error of estimate=0.537);

– *distance value GL_1*=2.772 - 0.135×Max1-APog - 0.596×MdLD43 - 1.583×MdK15 + 0.967×VoLK11 + 0.761×MdLK42 + 1.660×VoK43 + 0.708×MdLK11 + 0.150×Xi-OcP (R^2=0.894, $F_{(8.21)}$=22.25, p<0.001, Std.Error of estimate=0.690);

– *distance value GL_2*=1.254 + 3.669×MdK13 + 0.194×MeSgo-POr + 0.088×Go-CF - 2.622×MdK16 - 1.981×MdC42 + 1.133×MdK46 (R^2=0.793, $F_{(6.23)}$=14.69, p<0.001, Std.Error of estimate=1.073);

– *distance value GL_3*=45.09 - 0.238×POr-NA + 3.287×MdK43 - 2.067×MdK45 - 0.455×MdLD41 - 1.313×MdC42 + 0.918×MdK46 - 0.997×MdC13 (R^2=0.850, $F_{(7.22)}$=17.86, p<0.001, Std.Error of estimate=0.863);

where, here and in the following equations, R^2 – coefficient of determination; $F_{(!)}$=! – critical $_{(!)}$ and obtained (!) Fisher's test value; p – confidence level; Std.Error of estimate – standard error of estimate.

Thus, using step-by-step regression analysis, all 18 possible reliable (in all cases $p<0.001$) highly informative models (R^2= from 0.626 to 0.913) of linear dimensions necessary for constructing the correct shape of the dental arch, depending on the features of teleradiometric indicators according to the Ricketts method and computed tomography dimensions of the teeth, were constructed in Ukrainian girls with a physiological bite and a very wide facial type. When analyzing the occurrence of teleradiometric parameters according to the Ricketts method and computed tomography dimensions of teeth in models in girls with a very wide face type, the following percentage of occurrence of these indicators was established: teleradiometric parameters according to the Ricketts method (34.71 % of all independent variables), width of the tooth crown in the mesio-distal direction (24.79 % of all independent variables), width of the tooth crown in the vestibulo-oral direction (13.22 % of all independent variables), distance from the incisal edge to the apex of the tooth root (6.61 % of all independent variables), distance from the incisal edge to the dentino-enamel border line of the tooth in the vestibulo-oral direction (5.79 % of all independent variables), width of the dentino-enamel border of the tooth in the mesio-distal direction (4.96 % of all independent variables), distance from the incisal edge to the dentino-enamel border line of the tooth dentino-enamel border of the tooth in the mesio-distal direction to the apex of the tooth root (4.13 % of all independent variables), distance from the dentino-enamel border line of the tooth in the mesio-distal or vestibulo-oral directions to the apex of the tooth root (2.48 % of all independent variables each), width of the dentino-enamel border of the tooth in the vestibulo-oral direction (0.83 % of all independent variables). When analyzing the occurrence of the corresponding teeth in the models in girls with a very wide face type, the following percentage of occurrence of these indicators was established: upper incisors (15.70 % of all independent variables – 10.74 % central incisors and 4.96 % lateral incisors), lower incisors (12.40 % of all independent variables – 6.61 % central incisors and 5.79 % lateral incisors), upper canines (7.44 % of all independent variables), lower canines (6.61 % of all independent variables), upper premolars (6.61 % of all independent variables – 0.83 % first and 5.79 % second), lower premolars (8.26 % of all independent variables – 2.48 % first and 5.79 % second), upper molars (5.79 % of all independent variables), lower molars (2.48 % of all independent variables).

In previous studies, all 18 possible reliable highly informative regression models (R^2= from 0.660 to 0.950, $p<0.001$ in all cases) were also built in Ukrainian girls with physiological bite and wide face type, which most often included teleradiometric indicators according to the Ricketts method (37.50 %), the width of the tooth crown in the mesiodistal direction (18.75 %), the distance from the cutting edge to the dentinoenamel border line of the tooth in the mesiodistal direction to the apex of the tooth root (9.82 %), upper and lower incisors (27.68 % and 10.71 %, respectively) [5].

The results obtained are consistent with data on morphological and functional differences between human somatotypes. One study conducted among practically healthy women with a mesomorphic body type showed a strong positive relationship between linear body dimensions (e.g., trunk length and chest circumference) and the level of emotional stability ($r=0.78$; $p<0.01$). This indicates the presence of systemic relationships between anthropometric indicators and psychophysiological parameters, which may have a similar nature in relation to the structures of the skull and face [3]. In a study that studied adolescents of the Ngamo people in Nigeria, a comparative analysis of 13 head and face parameters among individuals of different somatotypes was conducted. It was found that mesomorphs had significantly greater intertemporal width ($M=13.32\pm0.78$ cm) compared to ectomorphs ($M=11.79\pm0.64$ cm; $p<0.001$), as well as higher facial height. The relationship between body type and craniofacial characteristics was statistically significant ($\chi^2=14.63$; $p<0.05$), which confirms the idea of morphological consistency of the forming mechanisms [7]. No less convincing results were obtained in a study devoted to the morphometry of the periocular area. In a group of young healthy people, it was found that the width of the intermaxillary distance in mesomorphs exceeded the corresponding indicator in ectomorphs by an average of 2.6 mm ($p<0.01$), while the length of the palpebral fissure was greater by 1.9 mm ($p<0.05$). The work emphasizes the importance of somatotype as one of the independent predictors of anatomical variability of the upper third of the face [10].

A separate area of research concerns the external structure of the ear. In particular, it was found that in individuals with a mesomorphic somatotype, the length of the auricle was on average 6.27 cm, which is a statistically significantly higher value than in representatives of the ectomorphic type (5.82 cm; $p=0.03$). An increase in the ear index was also observed, demonstrating the predominance of more massive features in carriers of a mesomorphic physique [11]. These anatomical characteristics indicate that individuals with a broad face, who usually belong to this group, probably have other signs of craniofacial development, which is reflected in the configuration of the dental arch.

In men from Podillia of different somatotypes, the sizes of the pancreas and gallbladder were determined sonographically. It was recorded that in mesomorphs the length of the head of the pancreas was

3.48±0.05 cm, while in ectomorphs it was 2.91±0.04 cm ($p<0.05$). Although the study was not aimed at studying the structures of the head, the data obtained demonstrate a systematic preference for volumetric anatomical formations within one somatotype, which can also be traced in the configuration of the bone and soft tissues of the facial skeleton [8].

In the work of Zhao-xia S. U. et al. studied the features of the soft tissue facial profile of students of Han nationality with different somatotypes. In the mesomorph group, higher values of the nasolabial angle (130.6±1.2 °) and nose length were recorded, as well as a more pronounced zygomatic contour compared to ectomorphs. Such differences allow us to assert that the somatotype directly influences the architectonics of the face and forms the prerequisites for the emergence of anatomical variability within the normal range [14].

Thus, studies devoted to the relationships between the somatotype and body morphology confirm the presence of stable associations between the type of physique and the dimensions of both internal organs and craniofacial structures. This allows us to assume that the parameters of the dental arch, as part of a holistic morphofunctional system, can also be predicted on the basis of typical somatotype features using regression analysis.

Conclusions

1. In Ukrainian girls with a physiological bite and a very wide face type, all 18 possible highly informative (R^2= from 0.626 to 0.913) reliable (in all cases $p<0.001$) regression models of linear dimensions necessary for constructing the correct shape of the dental arch depending on the features of teleradiometric indicators according to the Ricketts method and computed tomography dimensions of the teeth were constructed.

2. The constructed models most often include teleradiometric indicators according to the Ricketts method (34.71 % of all independent variables), tooth crown width in the mesio-distal direction (24.79 % of all independent variables), tooth crown width in the vestibulo-oral direction (13.22 % of all independent variables), upper incisors and lower incisors (15.70 % and 12.40 % of all independent variables, respectively).

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