ORIGINAL ARTICLE

MATHEMATICAL MODELING OF TELEROENTGENOGRAPHIC PARAMETERS ACCORDING TO THE METHOD OF SCHWARZ A. M. DEPENDING ON THE BASIC CEPHALOMETRIC PARAMETERS IN UKRAINIAN YOUNG MEN AND YOUNG WOMEN WITH DIFFERENT FACE TYPES

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ABSTRACT

The aim: Is development and analysis of regression models of teleroentgenographic indices according to Schwarz A. M., which can be adjusted during surgery depending on the parameters that usually do not change in Ukrainian young men and young women with with normal occlusion close to orthognathic occlusion and different facial types.

Materials and methods: Teleroentgenographic indices were obtained using a dental cone-beam tomograph Veraviewepocs 3D Morita and studied in 49 young men and 76 young women with normal occlusion close to orthognathic. Persons were divided into groups with different face types according to the recommendations of Schwarz A. M. In the license package "Statistica 6.0", regression models of teleroentgenographic indices were built according to Schwarz A. M.

Results: For young men with orthognathic occlusion and with different types of faces according to Schwarz A. M. constructed 10 of 27 possible reliable regression models of the group of teleroentgenographic indicators, which can be corrected during surgical, orthopedic interventions in dentistry depending on the group of basic, invariable cephalometric indicators greater than 0.6 (R^2 = from 0.609 to 0.996); and in young women with different face types, 8 of the 27 possible reliable regression models in which the coefficient of determination is greater than 0.6 (R^2 = from 0.642 to 0.986).

Conclusions: The developed regression models provide the most individualized approach in determining the method and scope of the required dental intervention.

KEY WORDS: teleroentgenographic indices, orthognathic bite, face type

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INTRODUCTION

At the present stage, the activities of orthodontists, orthopedists, specialists in maxillofacial surgery, cosmetic surgeons are impossible without taking into account the cephalometric and gnatometric parameters of the patient [1]. One of the most valuable and informative methods of X-ray examinations, both in practical dentistry and in scientific developments, is the method of lateral teleroentgenography, which provides opportunities to obtain qualitative and quantitative characteristics of bone cephalometric parameters, indicators of the dental apparatus and soft tissues of the face [2, 3, 4]. Until now, there is no single unified method of cephalometric analysis, and numerous author's methods of such analysis require constant updating of data, development of their regulatory framework. After all, as established in numerous studies, the results of even the same methods of analysis differ significantly depending on racial, age, sex, ethnic, population and other characteristics [4, 5, 6].

Therefore, in recent years, much attention has been paid to the direction of research on mathematical modeling of appropriate cephalometric parameters and indicators of the dental-jaw apparatus in an individual, obtained using different methods of cephalometric analysis [7, 8].

THE AIM

The aim – development and analysis of regression models of teleroentgenographic indices according to Schwarz A. M., which can be adjusted during surgery depending on the parameters that usually do not change in Ukrainian young men and young women with normal occlusion close to orthognathic occlusion and different facial types.

MATERIALS AND METHODS

Lateral teleroentgenograms of the head were studied in 49 young men aged 17 to 21 years and 76 young women aged 16 to 20 years (part of the primary cephalometric parameters was obtained from the data bank of the research center of National Pirogov Memorial Medical University,

Vinnytsya) with normal occlusion close to orthognathic occlusion. Teleroentgenograms were obtained using a dental cone-beam tomograph Veraviewepocs 3D Morita (Japan) and analyzed using licensed medical software OnyxCeph$^{3™}$, version 3DPro (Image Instruments GmbH, Germany). Young men and young women were divided into groups with different face types according to the recommendations of Schwarz A. M. [9]: 1 face type (back face type by Schwarz A. M.) – 13 young men or 23 young women, 2 face type (average face type by Schwarz A. M.) – 18 young men or 24 young women and 3 face type (front face type by Schwarz A. M.) – 18 young men or 29 young women.

Measurements were performed according to the recommendations of Schwarz A. M. [9, 10]. Cephalometric points were determined due to the recommendations of Phulari B. S. [11] and Doroshenko S. I. and Kulginsky E. A. [12].

The first group of studied indices included metric parameters of the skull from the methods of Jarabak J. R. (1972), Burstone C. J. (1967), Bjork A. (1966), Ricketts R. M. (1961), Steiner C. C. (1959) and Schwarz A. M. (1960, 1961). These indices are basic in the cephalometric analysis, concerning them on lateral teleroentgenograms define position, an inclination of gnatic structures. The second group of indices is teleroentgenographic indices of the upper and lower jaws, interjaw indicators according to the method of Schwarz A. M., which are most often determined during surgery and which can be corrected by methods of surgical stomatology.

Carried out mathematical modeling of the following indices of the second group (depending on the basic cephalometric indicators of the first group): distance Max (length of the upper jaw) – distance from the constructive point apMax to the point PNS (mm); angle F (front angle) – is formed by lines Se-N and N–A and determines the location of the anterior contour of the upper jaw in the boom plane to the base of the skull (°); angle I (inclination angle) – determines the angle of inclination of the upper jaw (spinal plane) to the nasal perpendicular (°); distance L_Mand (length of mandible) – length of the mandible (distance from the projection of the Pog point on the line tGo-Me to the point tGo) (mm); angle G (gonial angle, angle of the mandible) – is formed by the lines ppCond-MT2 and T2-Me, which intersect at the point tGoS (°); distance R.asc. (length of the mandibular branch) – the distance from the design point R.asc to the design point tGoS (mm); angle B (basal angle) – indicates the angle between the upper and lower jaws ((formed by the lines ANS-PNS (palatal plane SpP) and Im-Me (mandibular plane MPS according to Schwarz)) (°); angle MM (maxillary mandibular angle) – define the angle at which the upper jaw is located relative to the lower jaw in the sagittal plane (formed by lines AB and ANS-PNS) (°); angle T (profile angle T) – formed by lines Sn-Pog' and Pn (nasal perpendicular) (°).

The Biomedical Ethics Commission of National Pirogov Memorial Medical University, Vinnytsya, Ukraine has established that the conducted research and applied research methods correspond to the international and domestic bioethical and moral and legal requirements and laws of Ukraine (protocol №8 dated 5.10.2017).

Regression models of individual teleroentgenographic indicators in young men and young women, inhabitants of Ukraine are built in the license package "Statistica 6.0". In the regression analysis the following conditions were considered: the final variant of the obtained equation must have a coefficient of determination (R^2) of at least 0.6; an F-criterion value of at least 3.0; the number of free members should be as low as possible.

RESULTS

In Ukrainian young men and young women with different face types, reliable regression models of teleroentgenographic indicators of the upper and lower jaws according to Schwarz A. M. (in which the coefficient of determination is greater than 0.6), which can be corrected during dental surgery, depending on the basic cephalometric parameters have form of the following linear equations.

For young men with the first type of face:

G = 74.29 + 1.133×POr-NBa + 0.197×S-ar:ar-Go – 0.737×ar-Go – 1.030×P-PTV (R^2=0.763; $F_{(4.8)}$=6.434; p<0.05; Error of estimate=3.015);

Length of Mandible = 128.0 + 1.234×N-S-Ar – 1.285×H – 0.646×N-S-Ba (R^2=0.801; $F_{(3.9)}$=12.09; p<0.01; Error of estimate=2.236);

Max = -49.80 + 1.794×S-E + 8.739×N-S:S-Ar' + 0.222×N-S-Ar (R^2=0.878; $F_{(3.9)}$=21.50; p<0.001; Error of estimate=1.024);

R.asc. = 72.56 – 0.577×S-ar:ar-Go + 1.226×S-ar + 0.305×ar-Go – 0.450×N-CC (R^2=0.961; $F_{(4.8)}$=49.24; p<0.001; Error of estimate=1.127);

where here and in the future, R^2 – coefficient of determination; $F_{(!,!!)}$=!!,!! – critical $_{(!,!!)}$ and received (!!,!!) value of the Fisher test; St. Error of estimate – standard error of the standardized regression coefficient; POr-NBa (cranial angle of inclination according to Ricketts R. M.) – the angle formed by lines Po-Or and Ba-N (°); S-ar:ar-Go (indicator S-ar:ar-Go according to Jarabak J. R.) – indicator of the ratio of distances S-ar and ar-Go; ar-Go (the length of the branch of the mandible according to Burstone C. J.) – the distance from point Ar to point Go (mm); P-PTV (distance P-PTV according to Ricketts R. M.) – the distance from point Po to point Pt, parallel to the Frankfurt plane (mm); N-S-Ar (saddle angle according to Bjork A.) – the angle between the anterior cranial base and the lateral cranial base, which determines the position of the temporomandibular joint and glenoid fossae and is formed by lines N-S and S-ar (°); H (angle H according to Schwarz A. M.) – the angle formed by the lines Po-Or and Pn, determines the angle of inclination of the Frankfurt plane to the base of the skull (°); S-E (the length of the back of the skull base according to Steiner C. C.) – the distance from point S to the constructive point E (mm); N-S:S-Ar' (indicator N-S:S-Ar' according to Bjork A.) – indicator of the ratio of distances ar'-S and N-S; S-ar (the length of the lateral cranial base according to Jarabak J. R.) – the distance from point S to point ar (mm); N-CC (anterior length of the base of the skull according to Ricketts R. M.) – the distance from point N to point CC (mm).

In young men with the first type of face, the coefficients of determination of the regression equations of the angles B, I and T are from 0.307 to 0.504 and therefore do not matter for practical use by dentists. Regression equations for MM and F angles in young men with the first type of face were not constructed at all.

For young men with the second type of face:

Length of Mandible = -49.86 + 1.140×N-Se + 0.373×N-S-Ba (R^2=0.939; $F_{(2.15)}$=115.2; p<0.001; Error of estimate=4.678);

Max = -22.53 + 0.741×N-CC + 0.217×N-S-Ar (R^2=0.982; $F_{(2.15)}$=415.0; p<0.001; Error of estimate=1.462);

R.asc. = -8.928 + 0.954×ar-Go + 0.430×POr-NBa + 0.199×N-S (R^2=0.996; $F_{(3.14)}$=1059.6; p<0.001; Error of estimate=1.134);

MM =135.7 – 7.691×N-S:S-Ar' + 0.287×P-PTV (R^2=0.609; $F_{(2.15)}$=11.66; p<0.001; Error of estimate=3.734);

where here and in the future, N-Se (the length of the front of the skull base according to Schwarz A. M.) – the distance from point Se to point N (mm); N-S-Ba (angle N-S-Ba according to Bjork A.) – the angle formed by the lines S-N (anterior part of the base of the skull) and S-Ba (°); N-S (the length of the anterior cranial base according to Jarabak J. R.) – the distance from point N to point S (mm).

In young men with the second type of face, the coefficients of determination of the regression equations of the angles B, G, F and T are from 0.127 to 0.288 and therefore do not matter for practical use by dentists. The regression equation for angle I in young men with the second type of face was not constructed.

For young men with the third type of face:

R.asc. = -69.99 + 1.185×ar-Go + 0.292×S-ar:ar-Go + 0.581×H (R^2=0.907; $F_{(3.14)}$=45.63; p<0.001; Error of estimate=1.531);

T = 9.144 – 1.034×ar-Go + 0.731×H – 0.182×S-ar:ar-Go (R^2=0.609; $F_{(3.14)}$=7.257; p<0.01; Error of estimate=3.650).

In young people with the third type of face, the coefficients of determination of the regression equations of the angles B, I, G and MM and the distances Length of Mandible and Max are from 0.250 to 0.583 and therefore do not matter for practical use by dentists. The regression equation for the angle F in young men with the third type of face was not constructed.

For young women with the first type of face:

R.asc. = -14.61 + 0.872×ar-Go + 0.639×S-ar + 0.488×POr-NBa (R^2=0.822; $F_{(3.18)}$=27.65; p<0.001; Error of estimate=1.872);

MM = 158.7 – 0.606×H – 0.210×ar-Go – 0.482×P-PTV – 0.210×N-Se (R^2=0.642; $F_{(4.17)}$=7.611; p<0.01; Error of estimate=1.991);

In young women with the first type of face, the coefficients of determination of regression equations of angles B, G, F, I and T and distances Length of Mandible and Max were from 0.188 to 0.519 and therefore do not matter for practical use by dentists.

For young women with the second type of face:

Length of Mandible = 19.30 + 0.701×N-Se – 5.882×N-S:S-Ar' + 0.821×N-CC – 0.217×S-ar:ar-Go (R^2=0.884; $F_{(4.18)}$=34.20; p<0.001; Error of estimate=3.603);

Max = -7.176 + 0.124×S-ar:ar-Go + 0.662×N-S (R^2=0.936; $F_{(2.20)}$=146.2; p<0.001; Error of estimate=1.377);

R.asc. = -54.39 + 0.946×ar-Go + 0.538×S-ar + 0.504×H + 1.320×N-S:S-Ar' (R^2=0.986; $F_{(4.18)}$=315.2; p<0.001; Error of estimate=1.087).

In young women with the second type of face, the coefficients of determination of the regression equations of the angles B, G, MM, F, I and T are from 0.127 to 0.574 and therefore do not matter for practical use by dentists.

For young women with the third type of face:

Length of Mandible = -13.91 + 1.313×N-S (R^2=0.741; $F_{(1.27)}$=77.22; p<0.001; Error of estimate=3.623);

R.asc. = -44.23 + 0.825×N-S + 0.969×POr-NBa + 0.514×ar-Go (R^2=0.881; $F_{(3.25)}$=61.79; p<0.001; Error of estimate=2.557);

I = 135.4 – 0.669×H + 0.434×S-ar (R^2=0.656; $F_{(2.26)}$=24.77; p<0.001; Error of estimate=2.237).

In young women with the third type of face, the coefficients of determination of the regression equations of the angles B, G, MM, F and T and the distance Max are from 0.140 to 0.574 and therefore do not matter for practical use by dentists.

DISCUSSION

It should be noted that a number of researchers have simulated teleroentgenographic parameters, which may change as a result of surgery depending on the basic, usually unchanged cephalometric parameters in young Ukrainians using the methods of cephalometric analysis according to Ricketts R. M. [13], according to Burstone C. J. [14] and according to Harvold E. P. [15]. However, with the same modeling according to the methods of McNamara J., Downs B. B., Schmuth P. F., Holdway R. A., Steiner C. C., Tweed C. H. and Schwarz A. M. (without taking into account the type and profile of the face) out of 43 possible models, only 4 models with a coefficient of determination greater than 0.5 were constructed for young men, and no model with a coefficient of determination greater than 0.5 was obtained for young women. [16].

As a result of our step-by-step regression analysis for the development of models of teleroentgenographic indicators of the upper and lower jaw and interjaw indicators, which were included into the second group according to Schwarz A. M. (which can be adjusted during dental surgery) depending on cephalometric indicators of the first group (basic indicators which usually do not change during surgical interventions in surgical dentistry) in young men with orthognathic occlusion with different face types, 10 of the 27 possible reliable regression models in which the coefficient of determination is greater than 0.6 (R^2 = from 0.609 to 0.996) were build. In young women with different face types, 8 out of 27 possible reliable regression models were built, with a coefficient of determination greater than 0.6 (R^2 = from 0.642 to 0.986), which allows their use in practice.

Thus, young men received more models than young women, and the coefficients of determination in the models of young men and young women were almost the same. Ac-

cording to other researchers who also performed modeling, but according to other methods of cephalometric analysis and other indicators of the first and second groups in Ukrainian young men and young women with orthognathic occlusion, there were also more models in young men than in young women according to Harvold E. P. method [15], moreover, with higher coefficients of determination in young men (R^2 = from 0.616 to 0.940) than in young women (R^2 = 0.857 and 0.792); and the same number of models, but with higher coefficients of determination in young men than in young women in the case of cephalometric analysis according to Burstone C. J. (R^2, respectively, from 0.806 to 0.918 in young men and from 0.510 to 0.768 in young women) [14], or according to Ricketts R. M. (in young men R^2 = 0.884 and 0.928, and young women – 0.735 and 0.719) [13].

Despite the fact that according to the Schwarz A. M. method we studied 3 indicators of distances and 6 indicators of angles, both in young men and young women, most models with a coefficient of determination greater than 0.6 are built for indicators of linear distances: in young men of different face types – 7 models out of 9 possible, and for young women – 6 models out of 9 possible.

It should be noted that for the distance R.asc. developed models with a coefficient of determination greater than 0.6 for both young men (R^2, respectively, 0.961, 0.996 and 0.907), and for young women (R^2, respectively, 0.822, 0.986 and 0.881) for all face types. For the Length of Mandible distance, regression equations with a coefficient of determination greater than 0.6 were constructed for young men with the first (R^2 = 0.801) and second (R^2 = 0.939) facial types and for young women with the second (R^2 = 0.884) and third (R^2 = 0.741) facial types, and for the distance Max – for young men with the first (R^2 = 0.878) and second (R^2 = 0.982) face types.

In young men with different face types, the constructed models of teleroentgenographic indicators, which were included in the second group according to the Schwarz A. M. method, most often include the following indicators of the first group: ar-Go distance according to Burstone C. J. (17.2 %), S-ar:ar-Go index according to Jarabak J. R (13.8 %) and angles H according to Shwars A. M. and NS-Ar according to Bjork A. (10.3 % each).

In young women, the models of teleroentgenographic indicators of the second group according to the method of Schwarz A. M. most often include the following indicators of the first group: ar-Go distance according to Burstone C. J. (17.4 %); distances N-S and S-ar according to Jarabak J. R. and angle H according to Shwars A. M. (13.0 % each). Instead, the distance S-E for Steiner C. C. and the angles N-S-Ar and N-S-Ba according to Bjork A. were never included to the models.

All presented mathematical models of teleroentgenographic indicators in Ukrainian young men and young women with different face types were developed for the first time and are completely original.

CONCLUSIONS

The development and application of regression models of teleroentgenographic parameters of the jaws depending on the basic cephalometric parameters taking into account sex and age, facial features of patients provides the most individualized approach in determining the method and the amount of surgical dental intervention if necessary to correct these indicators.

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