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MODELING OF GNATOMETRIC INDICES DEPENDING ON PARAMETERS OF BASAL CRANIAL STRUCTURES IN BOYS AND GIRLS WITH ORTHOGNATHIC BITE

Summary. For the possibility of forming an objective basis for determining the diagnosis and creating the ultimate goal of orthodontic treatment, it is necessary to have a clear understanding of the individual variables of the basic metric characteristics of certain individual parameters of bone structures and soft facial tissues.
The aim of the study – to construct and analyze the regression models of gnatometric indices, depending on the parameters of basal cranial structures in boys and girls with orthognathic bite.
Materials and Methods. Teleroentgenography and computed tomography studies were performed on 38 boys (aged from 17 to 21) and 55 girls (aged from 16 to 20 years) who had a physiological bite as close as possible to orthognathic. The construction of regression models of gnatometric indices, depending on the parameters of basal cranial structures, was carried out in the licensed package "Statistica 6.0".
Results and Discussion. As a result of the regression analysis conducted in the boys with orthognathic occlusion, the following models of gnatometric parameters were constructed depending on the parameters of the basal cranial structures: effective length of the maxilla = - (16.11+1.01)×distance Se_N + 0,45×magnitude of the base of the maxilla + 0.28×distance S_E (determination factor is 0.612); length of the upper jaw = - (15.42+0.50) ×distance Se_N + 0.50×the size of the base of the upper jaw (the determination coefficient is equal to 0.550); angle SND = 107.8 – 0.47×H-angle + 0.39×magnitude of the base of the upper jaw – 0.38×distance S_E (determination coefficient is equal to 0.502); distance S_L = (13.05+1.51) ×distance Se_N – 0.87×H-angle – 0.86×distance S_E + 0.63×magnitude of the base of the upper jaw (determination coefficient is 0.626).
Conclusions. Of the 43 possible regression models of gnatometric indices, depending on the parameters of the basal cranial structures in boys with orthognathic occlusion, only 4 valid models with a determination coefficient greater than 0.5 were constructed, namely, effective length of the upper jaw, maxilla length, SND angle and distance S_L. In girls with orthognathic bite, models with a determination coefficient greater than 0.5 are not built at all.

Key words: regression analysis; gnatometric indices; sizes of basal cranial structures; boys and girls with orthognathic bite.

INTRODUCTION The most valuable and accessible method for analyzing the ratio of cranio-facial structures is the lateral teleroentgenography, which allows obtaining standardized images of the bone and soft tissue structures of the patient's head and conduct their linear and angular metric research. With the onset of the application of this diagnostic method, average normative values were proposed that have significant fluctuations, depending on the recommendations of a particular author proposing their normative values, and which are usually considered as some mean value and its permissible deviations [8, 17, 24], or as the value determined by means of other more stable key indicators [18, 19, 23]. Some authors [7, 17] substantiate the expediency of using as the base plane – the Frankfurt horizontal, others suggest using structures located closer to the sagittal plane or on its own [4, 12]. The third group of researchers does not consider any normative values of a separate indicator and suggest to consider a whole complex of indicators, so-called floating norms, which should be in a harmonic ratio [15, 20].

The search for an understanding of the basic principles of development of the main department of a person is actively continuing and is now not limited to the study of only cranio-maxilla relations. It is also dedicated to the study of the connections of the craniofacial complex with the characteristics of the dental arch [25], the oropharynx [21], the dysfunction of the temporomandibular joint [3], and even the dependence of the condition of the teeth on the type of face growth [13].

But the most interesting and popular direction of research is the ability to determine the parameters of the tooth-jaw complex, which are prone to adverse phenotypic factors (bad habits, injuries, abnormalities of function, etc.) from the most resistant to external influences of structures. This structure is the basis of the skull, which plays a key role in the development of all its components [14]. It performs a unifying function in spatial and functional sense, supports the brain and allows the brain and the facial units to adapt and develop during formation.

The aim of the study – to construct and analyze the regression models of gnatometric indices, depending on the parameters of basal cranial structures in boys and girls with orthognathic bite.

MATERIALS AND METHODS In the course of the study, 38 young men (aged from 17 to 21 years) and 55 girls (aged from 16 to 20) were selected, having a physiological bite as close as possible to the orthognathic one, which is determined by 11 points of M. G. Bushan et al. [1], a harmonious face and an aesthetic smile. Teleroentgenography and computed tomography studies were conducted. For the teleroentgenography study, a dental cavity-ray tomography scanner Veraviewepocs 3D Morita (Japan) was used in a cephalometric study mode. Subsequently, OnyxCeph³™ software, 3DPro version, Image Instruments GmbH, Gemania were used for cephalometric analysis. Software license №NWNE-VS2J is registered at M. O. Dmitriev. The following methods of teleroentgenography analysis were used by A. M. Schwarz, J. Mc Namara, B. B. Downs, R. A. Holdway, P. F. Schmuth, C. C. Steiner and C. H. Tweed.

For a cone-ray computed tomography study, a dental cone-ray tomograph – Veraviewepocs 3D Morita in a computer tomography mode was used. The research was carried out within the following characteristics: voltage at generator 60-80 kV; current strength on generator 1-10 mA; focal spot 0.5 mm; exposure time at high quality mode was 9.4 s; the rotation angle at the tomographic study was 180 degrees; the size of the scanned part was 8x8cm; the minimum size of the voxel – the element of the three-dimensional image

was 0.125 x 0.125 x 0.125 mm. The data were stored in the i-Dixel database and a three-dimensional image was analyzed in the software package of the i-Dixel One Volume Viewer [Ver.1.5.0] J. Morita Mfg. Cor.

Actual image of measurements and the location of teleroentgenography and computed tomographic points are described in detail in previous studies [2].

The construction of regression models of gnatometric indices, depending on the parameters of the basal cranial structures, was carried out in the license package "Statistica 6.0".

RESULTS AND DISCUSSION The issue of development and the principles of the formation of the skull in general is constantly arousing interest and discussion among anatomists, physiologists and doctors whose professional activity is associated with changes in the bone and soft structures of the skull. Since the practical realization of accumulated knowledge in most cases occurs in the area of the facial skull, where there are usually high aesthetic demands, then, and accordingly, practitioners have questions that are clear, and in the metric sense, the definition of the necessary changes and modifications to be made for complete rehabilitation of the patient both in functional and aesthetic terms. And for the possibility of forming an objective basis for defining the diagnosis and creating the ultimate goal of the doctor's treatment, it is necessary to have a clear understanding of the individual variables of the main metric characteristics, and to have tools for identifying certain individual parameters of bone structures and soft facial tissues.

As a result of the regression analysis conducted in the *young men*, it was found that the dependent variable of the *models of effective length of the upper jaw* for 61.2 % depends on the total complex of basal cranial structures included in the regression polynomial (determination coefficient RI = 0.612). The part of the coefficients of this model has a sufficiently high reliability, only for the independent variable and distance S_E p>0.05. Given that F = 17.36, which exceeds the calculated value of Fisher's criterion (F critical is 3.33), we can assert that the regression linear polynomial is highly significant (p<0.001), which is confirmed by the results of the dispersion analysis. The model has the form of the following linear equation: *effective length of the upper jaw* = - 16.11 + 1.01 × distance Se_N + 0.45 × the size of the base of the upper jaw + 0.28 × distance S_E, where (here and thereafter) the sizes of the basal cranial structures – in mm.

In *young men*, the dependent variable of the *maxillary length model* of 55.0 % depends on the total complex of basal cranial structures included in the regression polynomial (determination coefficient RI = 0.550). Most of the coefficients of this model have a fairly high reliability, only for the independent variable p>0.05. Given that F = 20.80, which exceeds the calculated value of Fisher's criterion (F critical is 2.34), we can assert that the regression linear polynomial is highly significant (p<0,001), which is confirmed by the results of the dispersion analysis. The model has the form of the following linear equation: *length of the upper jaw* = - 15.42 + 0.50 × distance Se_N + 0.50 × the size of the base of the upper jaw.

In *young men*, the dependent variable of the angle SND model by 50.2 % depends on the total complex of basal cranial structures included in the regression polynomial (determination coefficient RI = 0.502). Most coefficients of this model have a high reliability, only for the distance S_E p>0.05. Taking into account that F = 11.08, which exceeds the calculated value of Fisher's criterion (F critical is 3.33), we can assert that the regression linear polynomial is highly significant (p<0.001), which is confirmed by the results of the dispersion analysis. The model has the form of the following linear equation: *angle SND* = 107.8 - 0,47 × H-angle + 0.39 × magnitude of the base of the upper jaw – 0.38 × distance S_E.

In *young men*, the dependent variable of the *distance S_L model* is by 62.6 % dependent on the total complex of basal cranial structures included in the regression polynomial (determination coefficient RI = 0.626). Most of the coefficients of this model have a fairly high reliability, only for the independent variable and the size of the base of the maxilla, p>0.05. Given that F = 13.40, which exceeds the calculated value of Fisher's criterion (F critical is 4.32), we can assert that the regression linear polynomial is highly significant (p<0.001), which is confirmed by the results of the dispersion analysis. The model has the form of the following linear equation: *distance S_L* = 13.05 + 1.51 × distance Se_N – 0.87 × H-angle – 0.86 × distance S_E + 0.63 × size of the base of the upper jaw.

All other models of gnatometric indices (39), depending on the parameters of basal cranial structures in men with orthognathic bite, have a determination coefficient of less than 0.5 and therefore have no practical significance for medicine. In girls with orthognathic bite, models of gnatometric indices are not constructed at all, depending on the parameters of the basal cranial structures with a determination coefficient greater than 0.5.

Many studies have been devoted to the study of the relationship between the teleroentgenography characteristics of the skull base and the metric characteristics of the tooth-jaw complex, but they are highly controversial in relation to the influence of the basal angle (which practically does not change with the growth of the child), the length of the anterior and posterior cranial bases on the formation of tooth-maxillary anomalies [6]. Studies by many scientists [9, 16] indicate a significant effect of the properties of the base of the skull on sagittal inter-jaw relationships.

In the work of G. B. Hopkin et al. [9] there is an evidence that the angle of the base of the skull clearly correlates with the type of tooth-jaw disease. So with progeny (the front position of the mandible, 3rd class by Engle), the BaSN angle is smaller in men and women (respectively 122.4° and 122.2°) than in the posterior position of the mandible (or second grade in Engle) at which the BaSN angle is more open and has larger values (respectively 126.7° and 128.8°). Similar results show the work of other researchers [10, 11].

At the same time, other studies [5, 26] show a lack of clear influence of the cranial angle on the tooth-jaw system. There were no differences between normal occlusion and different pathological classes in Engle.

This state of affairs can be explained by the fact that the research data were conducted in different ethnic and age groups, different samples and may be using different diagnostic approaches and methods of data analysis. After all, with the use of a more detailed approach, the results of research may be quite different, than when analyzing an entire heterogeneous population. So, in his studies, S. Sidiropoulou [22] came closer to correlation analysis and divided the subjects under the type of face. His scholarly works illustrated the dependence of the NSBA angle on the face type. For retrograde, orthognathic and prognostic types for men, the angle values are 133–138°, 126–132°, and 120–125°, and for women, they are 136–143°, 130–135°, and 122–129°, respectively.

It should be borne in mind that the craniofacial complex is a rather complicated structure for study, since it combines function and form, genetically determined parameters and those that are prone to external influence. The existence of such a controversial situation necessitates further detailed research in this direction.

CONCLUSIONS Among 43 possible regression models of gnatometric indices, depending on the parameters of the basal cranial structures in boys with orthognathic occlusion, only 4 valid models with a determination coefficient greater than 0.5 were constructed, namely: effective length of the upper jaw, maxilla length, SND angle and distance S_L. In girls with orthognathic bite, models with a determination coefficient greater than 0.5 are not constructed at all.

Prospects for further research consists in constructing regression models of the parameters of the position of the teeth that need to be determined for orthodontic treatment, depending on the key parameters of the skull and jaws.

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МОДЕЛЮВАННЯ ГНАТОМЕТРИЧНИХ ПОКАЗНИКІВ ЗАЛЕЖНО ВІД ПАРАМЕТРІВ БАЗАЛЬНИХ КРАНІАЛЬНИХ СТРУКТУР ЮНАКІВ ТА ДІВЧАТ З ОРТОГНАТИЧНИМ ПРИКУСОМ

Резюме. Для можливості формування об'єктивного підґрунтя визначення діагнозу та створення кінцевої мети лікування ортодонта, необхідно мати чітке розуміння про індивідуальні варіативні значення основних метричних характеристик певних індивідуальних показників кісткових структур та м'яких тканин лиця.
Мета дослідження – побудувати і провести аналіз регресійних моделей гнатометричних показників залежно від параметрів базальних краніальних структур у юнаків та дівчат із ортогнатичним прикусом.
Матеріали і методи. У 38 юнаків (віком від 17 до 21 року) та 55 дівчат (віком від 16 до 20 року), які мали фізіологічний прикус максимально наближений до ортогнатичного, було проведено телерентгенографічні та комп'ютернотомографічні дослідження. Побудову регресійних моделей гнатометричних показників залежно від параметрів базальних краніальних структур проведено в ліцензійному пакеті Statistica 6,0.
Результати досліджень та їх обговорення. У результаті проведеного регресійного аналізу в юнаків з ортогнатичним прикусом побудовано такі моделі гнатометричних показників залежно від параметрів базальних краніальних структур: ефективна довжина верхньої щелепи = -6,11+1,01×відстань Se_N+0,45×величину основи верхньої щелепи + 0,28×відстань S_E (коефіцієнт детермінації дорівнює 0,612); довжина верхньої щелепи = –15,42+0,50×відстань Se_N+0,50×величину основи верхньої щелепи (коефіцієнт детермінації дорівнює 0,550); кут SND = 107,8–0,47×H-кут + 0,39×величину основи верхньої щелепи – 0,38×відстань S_E (коефіцієнт детермінації дорівнює 0,502); відстань S_L = 13,05+1,51×відстань Se_N – 0,87×H-кут – 0,86×відстань S_E+0,63×величину основи верхньої щелепи (коефіцієнт детермінації дорівнює 0,626).
Висновки. Із 43 можливих регресійних моделей гнатометричних показників залежно від параметрів базальних краніальних структур у юнаків з ортогнатичним прикусом побудовано лише 4 достовірних моделі з коефіцієнтом детермінації більшим 0,5, а саме: ефективної довжини верхньої щелепи, довжини верхньої щелепи, кута SND та відстані S_L. У дівчат із ортогнатичним прикусом взагалі не побудовані моделі з коефіцієнтом детермінації більшим 0,5.

Ключові слова: регресійний аналіз; гнатометричні показники; розміри базальних краніальних структур; юнаки і дівчата з ортогнатичним прикусом.

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МОДЕЛИРОВАНИЕ ГНАТОМЕТРИЧЕСКИХ ПОКАЗАТЕЛЕЙ В ЗАВИСИМОСТИ ОТ ПАРАМЕТРОВ БАЗАЛЬНЫХ КРАНИАЛЬНЫХ СТРУКТУР ЮНОШЕЙ И ДЕВУШЕК ИЗ ОРТОГНАТИЧЕСКИМ ПРИКУСОМ

Резюме. Для возможности формирования объективного основания определения диагноза и создание конечной цели лечения ортодонта, необходимо иметь четкое понимание об индивидуальных вариативных значениях основных метрических характеристик определенных индивидуальных показателей костных структур и мягких тканей лица.
Цель исследования – построить и провести анализ регрессионных моделей гнатометрических показателей в зависимости от параметров базальных краниальных структур у юношей и девушек с ортогнатическим прикусом.
Материалы и методы. У 38 юношей (в возрасте от 17 до 21 года) и 55 девочек (в возрасте от 16 до 20 года), имевших физиологический прикус максимально приближенный к ортогнатическому, были проведены телерентгенографические и компьютернотомографические исследования. Построение регрессионных моделей гнатометрических показателей в зависимости от параметров базальных краниальных структур проведена в лицензионном пакете Statistica 6,0.
Результаты исследований и их обсуждение. В результате проведенного регрессионного анализа в юношей с ортогнатическим прикусом построены следующие модели гнатометрических показателей в зависимости от параметров базальных краниальных структур: эффективная длина верхней челюсти = -16,11+1,01×расстояние Se_N+0,45×величину основания верхней челюсти + 0,28×расстояние S_E (коэффициент детерминации равен 0,612); длина верхней челюсти = -15,42+0,50×расстояние Se_N + 0,50×величину основания верхней челюсти (коэффициент детерминации равен 0,550); угол SND = 107,8 - 0,47×H-угол+0,39×величину основания верхней челюсти – 0,38×расстояние S_E (коэффициент детерминации равен 0,502); расстояние S_L=13,05+1,51×расстояние Se_N – 0,87×H-угол – 0,86×расстояние S_E + 0,63×величину основания верхней челюсти (коэффициент детерминации равен 0,626).
Выводы. Из 43 возможных регрессионных моделей гнатометрических показателей в зависимости от параметров базальных краниальных структур у юношей с ортогнатическим прикусом построено только 4 достоверные модели с коэффициентом детерминации большим 0,5, а именно: эффективной длины верхней челюсти, длины верхней челюсти, угла SND и расстояния S_L. У девушек с ортогнатическим прикусом вообще не построены модели с коэффициентом детерминации большим 0,5.

Ключевые слова: регрессионный анализ; гнатометрические показатели; размеры базальных краниальных структур; юноши и девушки из ортогнатическом прикусом.