Determination of individual angular characteristics of the teeth positions according to the computer tomography in Ukrainian adolescents with orthognathic bite

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The lack of the ability to determine the individual standard angle characteristics of the position of the teeth and the technical provision of their control often does not lead to the expected result and in each case requires individualization, the vision of which is based, as a rule, on the experience and intuition of the doctor. In order to solve such a situation, in addition to improving the positioning protocols of the non-removable equipment, the physician should be able to clearly identify the individual angular characteristics of the tooth-jaw system. The purpose of the study - by studying computer tomography and cephalometric indices and conducting direct stepwise regression analysis to develop in Ukrainian adolescents with orthognathic bite mathematical models of individual angular positions of teeth.

Using the Veraviewepocs 3D device, Morita (Japan) at 38 young men (aged from 17 to 21) and 55 young women (aged from 16 to 20 years) with normal occlusion close to orthognathic bite received and analyzed dental tomograms and lateral teleroentgenograms. Cephalometric points and measurements were performed according to recommendations of A. M. Schwarz, J. McNamara, W. B. Downs, R. A. Holdway, G. P. F. Schmuth, C. C. Steiner and C. H. Tweed. Anatomical points were determined taking into account the recommendations of A. E. Athanasiou, S. I. Doroshenko and Y. A. Kulginsky. The simulation of CT indexes describing the position of individual teeth relative to each other, to the bone cranial structures and the profile of adolescents with orthognathic bite, depending on the metric characteristics of the skull, which are usually unchanged during surgical and orthodontic treatment, as well as the width, lengths, angles and positions of the upper and lower jaws that may be altered by orthodontic surgery done. The statistical processing of the obtained results was carried out in the license package "Statistica 6.0" using a direct stepwise regression analysis. It was found that in young men of 40 possible models, 23 were constructed with a determination coefficient $R^2$ of 0.557 to 0.832, while in young women, only 8 models with a determination coefficient $R^2$ of 0.581 to 0.832. Moreover, in the young men - of 10 possible 9 models of vestibular-tongue inclination of corresponding teeth ($R^2$ from 0.557 to 0.832) were constructed; out of 10 possible 5 models of mesio-distal inclination of corresponding teeth ($R^2$ from 0.558 to 0.769) constructed; of the possible 14 constructed 6 models of rotation of the corresponding teeth ($R^2$ from 0.579 to 0.737); and in young women - there are only 5 models of vestibular-tongue inclination of the corresponding teeth ($R^2$ from 0.603 to 0.665). In addition, in both young men and young women, models of the size of the inter-incision angle ($R^2$ 0.748 in young men and 0.581 in young women) were constructed, the magnitude of the angle of inclination of the lower canine in the jet plane ($R^2$ respectively 0.729 and 0.793), and the magnitude of the inclination of the closure planes relative to the palatal plane ($R^2$ respectively 0.808 and 0.832). In the analysis it was found that in young men, most frequently models included - indicator WITS (7.0%); angle GL_SNPOG (5.4%); distance S_E, angle ММ, angle NSBA (by 4.7%); angle AB_NPOG, angle N_POG, distance N_SE, coefficient N_SP_SP, etc.
Introduction

Cone-ray computed tomography provides significant advantages for working with images in orthodontics, allows you to describe the craniofacial anatomy more precisely and provide comprehensive information on anatomical relationships and individual patient characteristics for improved diagnosis, treatment planning and prediction of dental anomalies [5, 19, 23]. But the lack of standard assessment methods, the unified protocol of orthodontic research, the existence of various methods for obtaining a three-dimensional image and the impossibility of their association defines a set of tasks that need to be resolved for the widespread introduction of computed tomography into orthodontic and surgical practice [28]. The issues of determining and controlling the three-dimensional position of the teeth have always been central to clinical orthodontic practice. The main characteristics of the position of the central axis of the tooth in the form of various sets of standard characteristics formed the basis of the production of bracket systems in the form of a prescription, which determines the position of the tooth in relation to the orthodontic arc [21].

Difficulties in production, individual morphological variety of teeth, different variants of positioning lead to the fact that the doctor often fails or difficult to implement the bracketed angular characteristics. The lack of the ability to determine the individual standard angle characteristics of the position of the teeth and the technical provision of their control often does not lead to the expected result and in each case requires individualization, the vision of which is based, as a rule, on the experience and intuition of the doctor. In order to solve such a situation, in addition to improving the positioning protocols of the non-removable equipment, the physician should be able to clearly identify the individual angular characteristics of the tooth-jaw system.

The purpose of the study - by studying computer tomography and cephalometric indices and conducting direct stepwise regression analysis to develop in Ukrainian adolescents with orthognathic bite mathematical models of individual angular positions of teeth.

Materials and methods

Dental tomograms and side telerentgenograms were obtained and analyzed using the Verawviewepocs 3D device, Morita (Japan) in 38 young men (17 to 21 years of age) and 55 young women (aged 16 to 20 years) with normal occlusion close to orthognathic bite. Cephalometric points and measurements were performed according to recommendations of A. M. Schwarz, J. McNamara, W. B. Downs, R. A. Holdway, G. P. F. Schmuth, C. C. Steiner and C. H. Tweed [11, 14, 15, 24, 29, 30, 31, 33]. Anatomical points were determined taking into account the recommendations of A. E. Athanasiou [3], S. I. Doroshenko and Y. A. Kulginisky [10].

The analysis of telerentgenograms and the results of their researches for Ukrainian adolescents are described in detail and set out in a number of articles [6, 7, 8, 9, 12, 13]. The determined cephalometric indices were combined and then divided into three groups. The first group included metric characteristics of the skull, which usually do not change during surgical and orthodontic treatment. Most of these...
Fig. 2. Mesio-distal inclination $\text{I}!!$ of the corresponding tooth (56) ($\text{ANGUL} \_!!$) - formed by line $\text{I}!!\text{-Apx}!!$ (the central axis of the corresponding tooth) and perpendicular to the closure plane ($\text{OclPl}$) in the frontal area of the studied tooth (in the calculation the average value of the angle of the symmetrical teeth of the right side to left side on one jaw is then taken).

Fig. 3. Vestibular-lingual inclination $\text{I}!!$ of the corresponding tooth (57) ($\text{TORK}!!$) - formed by line $\text{I}!!\text{-Apx}!!$ (the central axis of the corresponding tooth) and perpendicular to the closure plane ($\text{OclPl}$) in a sagittal plane of investigating tooth (in the calculation the average value of the angle of the symmetrical teeth of the right side to left side on one jaw is then taken).

Fig. 4. Rotation $\text{II}$ of the corresponding tooth (58) ($\text{ROT}!!$) - formed by the median-sagittal plane of the tooth and the median-sagittal plane of the head, allows to determine the tooth rotation relative to the median-sagittal plane (in the calculation the average value of the angle of the symmetrical teeth of the right side to left side on one jaw is then taken).

Fig. 5. Angle of inclination of the upper canine in the sagittal plane (61) ($\text{MDYG13}$) - formed by lines $\text{I}13\text{-Apx}23$ and line $\text{ANS-PNS}$ in the sagittal projection (the angle formed by the central canine axis of the upper jaw and the palatal plane in the sagittal projection); angle of inclination of the lower canine in the sagittal plane (62) ($\text{MDYG33}$) - formed by lines $\text{I}43\text{-Apx}43$ and line $\text{ANS-PNS}$ in the sagittal projection (the angle formed by the central canine axis of the lower jaw and the palatal plane in the sagittal projection).

Fig. 6. Inter-cutter angle ($\text{YGRES}$) - formed by the central axes of the middle incisors of the upper $\text{I11-Apx11}$ and lower jaws $\text{I41-Apx41}$ (the indicator characterizes the angle formed by median cutters of the upper and lower jaws in the sagittal projection), (the calculation takes averaged magnitude of the angle of the symmetrical teeth of the right and left sides on one jaw).

Fig. 7. Determination of the inclination of the closure plane relative to the palatal plane.
that is, the accuracy of the description of the feature being simulated is not less than 50.0%; 2) - the value of the F-criterion is not less than 3.0, that is, the contribution of the variable to the regression should be sufficiently significant; 3) - the number of free members included in the polynomial should be as low as possible. In all cases, after selecting the equation of multiple regression, we carried out the analysis of the residues, since emissions can substantially shift the results and lead to erroneous conclusions. When the observations fell beyond the ±3 standard quadratic deviations from the mean value, we carried out a repeated analysis with and without emissions, in order to be sure that their impact on the bias of the final results is not affected.

**Results**

Results of simulation of CT indicators that characterize the position of individual teeth relative to each other, to the bone cranial structures and the profile of the appearance in young men and women with orthognathic bite, depending on the metric characteristics of the skull, which usually do not change during surgical and orthodontic treatment, as well as indicators of width, length, angles and positions of the upper and lower jaws that may be altered by orthodontic surgery, have the form of the following linear equations.

For young men:

\[
TORK_{11} = -10.08 + 1.190 x AB\_NPOG - 0.344 x T + 0.282 x G + 0.244 x N\_POG\_ + 0.662 x WITS + 0.121 x N\_SE (R^2=0.645; F_{(6,29)}=8.80; p<0.001; Error of estimate=2.780);
\]

\[
TORK_{12} = 47.84 + 1.546 x AB\_NPOG + 0.417 x PN\_A - 0.662 x S\_E - 1.027 x MAX\_MAND + 0.497 x AFH (R^2=0.557; F_{(6,30)}=7.53; p<0.001; Error of estimate=3.040);
\]

\[
TORK_{13} = 57.67 - 0.395 x N\_POG\_ - 0.780 x NL\_NSL - 0.422 x LPALAT - 0.576 x WITS - 0.342 x COND\_GN + 0.460 x N\_SE (R^2=0.604; F_{(6,29)}=7.36; p<0.001; Error of estimate=2.791);
\]

\[
TORK_{14} = -21.60 + 1.188 x PFH + 0.577 x FMA - 0.769 x COND\_GN + 0.472 x SND + 1.095 x ML\_NL - 0.769 x B (R^2=0.832; F_{(6,29)}=23.96; p<0.001; Error of estimate=1.885);
\]

\[
TORK_{15} = 6.657 - 0.920 x COND\_A + 0.329 x PFH + 0.848 x N\_SE + 1.760 x SNA - 0.368 x MAND - 1.310 x F (R^2=0.715; F_{(6,29)}=12.11; p<0.001; Error of estimate=2.628);
\]

\[
TORK_{41} = -6.068 + 1.718 x WITS + 0.743 x COND\_A - 0.551 x ANS\_ME (R^2=0.719; F_{(6,29)}=27.23; p<0.001; Error of estimate=3.955);
\]

\[
TORK_{42} = 47.98 - 0.938 x AB\_NPOG - 1.314 x ML\_NSL + 0.685 x S\_E + 0.373 x N\_POG\_ + 0.509 x NBA\_PTGN + 1.276 x SN\_GOGN (R^2=0.815; F_{(6,29)}=21.25; p<0.001; Error of estimate=2.612);
\]

\[
TORK_{43} = -121.5 + 0.664 x MM - 2.228 x ML\_NL + 1.823 x SN\_GOGN + 0.240 x MAX + 0.218 x NSBA + 0.362 x G (R^2=0.762; F_{(6,29)}=15.48; p<0.001; Error of estimate=2.360);
\]

\[
TORK_{44} = -2.185 - 0.353 x G + 0.670 x NSBA + 0.443 x GL\_SNPOG - 0.548 x H + 0.216 x PFH (R^2=0.739; F_{(6,30)}=16.99; p<0.001; Error of estimate=2.487);
\]

\[
\text{ANGUL}_{12} = -71.25 + 0.507 x ARGOME + 0.586 x MAND + 0.478 x WITS - 0.191 x GL\_SNPOG - 0.218 x COND\_GN
\]
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Regression models of all other CT indicators that characterize the position of individual teeth in young men and women with orthognathic bite have a determination coefficient of less than 0.5 and therefore not significant for practical dentistry.

**Discussion**

Today, at the disposal of the orthodontist doctor available bracket systems with various unified characteristics that were proposed by various researchers [1]. With the availability and wider use of dental computer tomography, doctors have developed a tool to control the position of the roots of the teeth after orthodontic treatment, even by conducting only one preliminary diagnostic radiological examination [20].

By conducting an analytical analysis of the treatment outcomes, more and more studies appear that present unexpected findings. So Jain M. et al. [16] argues that the use of braces with different authoring prescriptions does not affect the overall clinical outcome and the quality of treatment depends entirely on the judgment of the clinician and his experience, and that the use of standard systems, even with given angular characteristics, still requires individual arc correction [34]. A number of studies prove the inconsistency of the angular characteristics of the standard braces that are obtained by teeth at the end of the orthodontic treatment [4, 26].

The existence of such a situation can be explained by the absence of taking into account the variations of the individual anatomy of the teeth when positioning the bracket [27], the presence of errors in various manufacturers, which under one type of prescription can produce different angular characteristics [2, 25] and the impossibility of using one standard and unified system for biological diversity various variations and types of anatomical structure of the tooth-jaw system. So, a number of studies indicate that the normative characteristics of the spatial position of the teeth differ significantly in different races and ethnic groups [18, 22] and require the study and development of updated indicators [32]. It is also noted that there is an individual variation regarding the angular positions of the teeth [17].
which necessitates the development of individual prognostic techniques.

In our study, based on the peculiarities of the metric characteristics of the skull, which usually do not change during surgical and orthodontic treatment, as well as the parameters of the width, length, angles and position of the upper and lower jaws, which may be altered by orthodontic surgery, using the stepwise regression method with inclusion, in young men and women, reliable models of CT-indicators that characterize the position of individual teeth relative to each other, to the bony cranial structures and profile of the face are developed. It was established that in young men from 40 possible models, 23 were constructed with determination coefficient R² from 0.557 to 0.832, while young women had only 8 models with determination coefficient R² from 0.581 to 0.832. Moreover, in young men - out of 10 possible 9 models of vestibular-tongue inclination of corresponding teeth were constructed (R² from 0.557 to 0.832); out of 10 possible 5 models of mesio-distal inclination of corresponding teeth (R² from 0.558 to 0.769) were constructed; of the possible 14 constructed 6 models of rotation of the corresponding teeth (R² from 0.579 to 0.737); and in young women - only 5 models of the vestibular-tongue inclination of the corresponding teeth (R² from 0.603 to 0.665). In addition, in both in young men and women, models of the magnitude of the inter-incision angle (R² 0.748 in young men and 0.581 in young women), the magnitude of the angle of inclination of the lower canine in the jet plane (R² respectively 0.729 and 0.793) and the values of the inclination of the closing plane relative to the palatal plane (R² is respectively 0.808 and 0.832).

The analysis found that in young men models most often included - the WITS score, indicating a linear inclination of the lower jaw relative to each other, to the bony cranial structures and profile of the face, 23 with a determination coefficient R² of 0.557 to 0.832 were constructed, and in young women - only 8 models with determination coefficient R² from 0.581 to 0.832.

In further research, it is necessary to develop a computer program that will allow orthodontists to automatically calculate the necessary CT indicators that characterize the position of individual teeth relative to each other, to the bone cranial structures and profile of the face, which will enable the dentist to achieve the treatment of maximum physiological and aesthetic results.

**Conclusions**

1. In young men with normal occlusion close to orthognathic bite of 40 possible regression models of CT indicators that characterize the position of individual teeth relative to each other, to the bone cranial structures and profile of the face, 23 with a determination coefficient R² of 0.557 to 0.832 were constructed, and in young women - only 8 models with determination coefficient R² from 0.581 to 0.832.

2. In young men, among the metric characteristics of the skull, which usually do not change during surgical and orthodontic treatment, as well as the parameters of the width, length, angles and position of the upper and lower jaws that may be altered by orthodontic surgery models most commonly included - indicator WITS (7.0%), angle GL_SNPOG (5.4%); distance S_E, angle MM and angle NSBA (by 4.7%), angle AB_NPOG, angle N_POG_ , distance N_SE, coefficient N_SP_SP and angle P_OR_N (by 3.9%); and in young women - angle N_POG_ (14.3%), angle AB_NPOG (10.2%), indicator WITS (8.2%), angle MM, angle ANB and length of the branch of the mandible R_ASC (by 6.1%).

**References**


Нормальною оклюзією наближену до ортогнатичного прикусу були отримані та проаналізовані дентальні томограми та дівчат України з ортогнатичним прикусом математичні моделі індивідуальних кутових положень зубів. За допомогою томографічних та цефалометричних показників і проведення прямого покрокового регресійного аналізу розробити у юнаків індивідуальні кутові характеристики зубощелепної системи. Мета дослідження - шляхом вивчення ком'ютерно-вдосконалення протоколів позиціювання незнімної апаратури лікарю необхідно мати можливість чіткого визначення забезпечення їх контролю часто не призводить до отримання очікуваного результату і в кожному випадку потребує.

ВІЗНАЧЕННЯ ІНДИВІДУАЛЬНИХ КУТОВИХ ХАРАКТЕРИСТИК ПОЛОЖЕНЬ ЗУБІВ ЗА ДАНИМИ КОМ'ЮТЕРНОЇ ТОМОГРАФІЇ УКРАЇНСЬКИХ ЮНАКІВ И ДІВЧАТ ИЗ ОРТОГНАТІЧНИМ ПРИКУСОМ

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Відсутність можливості визначення індивідуальних нормативних кутових характеристик положень зубів та технічне забезпечення їх контролю часто не призводить до отримання очікуваного результату і в кожному випадку потребує індивідуалізації, збільшення якої базується, як правило, на досвіді та інтуїції лікаря. Для вирішення цієї проблеми відбувся широкий спектр досліджень, які наведені у цьому статті. Вивчення впливу оклізії та інших факторів на положення зубів встановлено, що індивідуальні кутові характеристики зуба в значній мірі залежать від їхнього положення.

Більш детальні дослідження відбувалися в рамках проекту "European Foundation for Ukrainian boys and girls". В ході цих досліджень було виявлено, що індивідуальні кутові характеристики зуба можуть впливати на функціональну активність та здоров'я зубних дуг. В результаті цих досліджень було зроблено висновок, що використання ком'ютерної томографії дозволяє отримати докладні дані про положення зубів.

Джерела:
ОПРЕДЕЛЕНИЕ ИНДИВИДУАЛЬНЫХ УГЛОВЫХ ХАРАКТЕРИСТИК ПОЛОЖЕНИЙ ЗУБОВ ПО ДАННЫМ КОМПЬЮТЕРНОЙ ТОМОГРАФИИ УКРАИНСКИХ ЮНОШЕЙ И ДЕВУШЕК С ОРТОГНАТИЧЕСКИМ ПРИКУСОМ

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Одной из острейших проблем при ортодонтическом лечении является определение индивидуальных угловых характеристик положения зубов, что позволяет врачу более точно определить необходимые для построения корректной трехмерной геометрии зубных дуг. Это необходимо для обеспечения необходимого для построения корректной трехмерной геометрии зубных дуг.

Цель исследования: разработать математические модели индивидуальных угловых характеристик положения зубов с помощью компьютерной томографии.

Метод: проведен прямой пошаговый регрессионный анализ с включением наиболее значимых показателей, полученных на основе компьютерной томографии и цефалометрии.

Результаты: математические модели индивидуальных угловых характеристик положения зубов построены на основе компьютерной томографии и цефалометрии.

Заключение: математические модели индивидуальных угловых характеристик положения зубов могут быть использованы для построения корректной трехмерной геометрии зубных дуг.

Ключевые слова: компьютерная томография, цефалометрия, юноши, девушки, ортогнатический прикус.