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ORIGINAL ARTICLE

Modeling of Central Incisors Position Indicators in boys and girls according to CC. Steiner method for Forensic Dental Identification

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Abstract

Personal identification remains one of the main focuses of forensic experts. A foreseeable method of conducting forensic research in the case of an unknown person's examination is a forensic dental examination. However, like other anthropometric studies, it requires adjustment for variables such as age, gender, and most importantly, ethnicity. The purpose of this study is to investigate the correct use of central incisors for Ukrainian boys and girls according to the data recommended by C.C.Steiner for their implementation in forensic identification. 93 lateral cephalometric images (38 boys and 55 girls) of 16-21 years of age with normal bite were examined. Cephalometric analysis was performed in OnyxCeph 3D pro. Statistical analysis and construction of regression models were carried out in the "Statistica 6.0" license package. A number of discrepancies in the percentile range of indexes of the position of the central incisors of the upper and lower jaws, depending on the value of the angle ANB in Ukrainian boys and girls with the results provided by CC. Steiner, were established. As a result of the regression analysis, reliable models of the characteristics of the position of the central incisors of the upper and lower jaws were constructed for Ukrainian boys and girls by Steiner method. The coefficient of determination in boys was found to be from 0.542 to 0.796; and in girls – from 0.503 to 0.622. The study confirmed the relationship of the angle ANB with angular (angles Max1_NA and Max1_SN) and linear (distance 1u_NA) characteristics of the position of the upper central incisors and the inclination angle of the lower central incisors (Mand1_NB). Ethnic differences in the characteristics of the position of the central incisors were determined depending on the magnitude of the ANB angle, and the general nature of the relationships of the main diagnostic parameters proposed by Steiner was confirmed. The results obtained allow their further use in routine practice for the purpose of forensic identification.

Keywords

Forensic Odontology; Identification; Cephalometry; Steiner method.

Introduction

Forensic medicine faces many of the challenges and problems of today: like armed conflicts, illegal migration, natural disasters, massive anthropogenic and natural disasters etc. In all these cases, the forensic expert deals with numerous fragmentary remains of human bodies, often in a state of corpse decay, which makes it impossible to identify the person by conventional methods by forensic expert. In such cases, forensic dentistry, which has become a full-fledged independent section of forensic medicine, is well established in different parts of world. Despite the fact that the first forensic dentist can be considered Paul Revere, who in 1775 identified the skeletonized remains of a person using a denture of the deceased, this discipline became independent only in 1898 after the publication of the monograph by cuban dentist Oscar Amoeda worked in France, who is rightly considered as the father of forensic dentistry.[1]

Forensic dental examination is a complex process that starts from the moment of the inspection of the corpse at the scene of incidence. An external examination of the corpse is carried out, and visible damage to the body, in particular teeth and damage resulting from the action of the teeth (bites) are described. The physical evidence is also recorded, as they may be displaced or deformed during the transportation of the corpse. The next stage, which takes place in the morgue, is a description of the dental formula, describes the traces of dental procedures, prostheses, etc. It should be noted separately that this stage is also accompanied by the participation of a forensic laboratory. At the last stage of forming the research part of the expert's opinion the analysis of the medical records of the deceased, archival data on dental manipulations is carried out. All the above procedures are performed according to DVI protocols.[2]

Not only teeth are used to identify a dead person; at the present stage of the development of forensic dentistry, work is

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underway to study the individual features of the morphology of the palate. According to the results of recent work, this method is specific and highly efficient.[3,4] In addition, the development of modern technology greatly expands the capabilities of forensic dentistry. The use of computer algorithms to process digital radiographs improves the accuracy of identification.[5]

A particular type of focus in forensic dentistry is the examination of bites. There are 4 classes of bite marks: from class 1, which is just visible traces of teeth to class 4 – when there remain clearly visible anatomical disruption, among which one can see their individual characteristics[6]. Bites are especially important material evidence in cases of sexual crimes, in particular in cases of child abuse and sexual homicide.[7-9]

In Ukraine as well as India the field of forensic dentistry has just begin to emerge. Kostenko S. and his co-authors proposed a new approach to the identification of dental composites using a spectrophotometric algorithm,[10] and Goncharuk-Khomyn et al.[11] modified the technique for determining dental age in children of the Transcarpathian region.

Considering that one of the main tools in forensic dentistry is radiological examination,[12] an affordable and inexpensive method, there is a need to improve its capabilities and adapt it to all possible capacities. One of the potential strengths of this method is the cephalometric study, which combines both cephalometric and odontometric parameters. CC.Steiner's cephalometric analysis proposed as early as 1953 has long been a reliable satellite of clinical dentistry and has the potential to be used for the purpose of forensic dental identification.[13] The development of models of this method, adapted for the Ukrainian population, and especially each individual historical and administrative, is a promising task for forensic dentistry.

The purpose of the study is to investigate the correct use of central incisors for Ukrainian boys and girls, according to the data recommended by CC.Steiner for their implementation in forensic identification.

Material and Methods

Using the Veraviewepocs 3D device, Morita (Japan), in 38 boys (17 to 21 years of age) and 55 girls (16 to 20 years of age) with normal occlusion, as close to orthognathic as possible, obtained and analyzed lateral radiographs according to CC. Steiner method.[13]

The Bioethics Committee of the National Pirogov Memorial Medical University, Vinnytsya found that the studies carried out corresponding to the bioethical and moral-law requirements of the Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine (1977) are in accordance with WHO and laws of Ukraine.

According to the method of CC.Steiner we determined the following indicators (Figures 1, 2): angle SNA – formed by lines S-N (Sella -Nasion line) and N-A (characterizing the location of the upper jaw with respect to the anterior cranial base in the anterior-posterior direction); SNB angle – formed by the lines S-N (anterior cranial base) and N-B (characterizing the location of the mandible with respect to the anterior cranial base in the anterior-posterior direction); ANB angle – inter-jaw angle formed by the lines A-N and N-B (indicates the inter-jaw ratio in the anterior-posterior direction); angle SND – formed by lines S-N and N-D (indicating the anterior-posterior arrangement of the symphysis (D – center of the symphysis) of the mandible to the anterior cranial base); inter-incisor angle II – formed by the central axes of the upper central (Ap1u-Is1u) and lower central (Ar1L-Is1L) incisors; angle SN_OcP – formed by lines apOcP-ppOcP and S-N (slope of the closing plane to the base of the skull); angle SN_GoGn – formed by lines Go-Gn and S-N (angle of inclination of the mandibular plane to the anterior cranial base); angle Max1_NA – formed by lines Ap1u-Is1u (inclination of the central axis of the upper central incisor) and N-A; angle Max1_SN – formed by lines Ap1u-Is1u (inclination of the central axis of the upper central incisor) and S-N; Mand1_NB angle – formed by the lines Ap1L-Is1L (inclination of the central axis of the lower central incisor) and N-B; distance 1u_NA – from point Ls1u to line N-A (determines anteroposterior location of crown of upper central incisor to line N-A); distance 1l_NB – from point Li1L to line N-B (determines the anteroposterior location of the crown of the lower central incisor to line N-B); distance Pog_NB – from the point Pog to the line N-B (characterizes the location of the chin to the line N-B); Holdaway ratio – the difference between the distances between the points Li1L and Pog to line N-B (characterizing the anterior posterior location of the crown of the lower central incisor relative to the size of the chin); the distance S_L is from the point S to the design point L, which is formed at the intersection of the perpendicular drawn from the point Pog to the line S-N; the distance S_E - from point S to the design point E, which is located at the intersection of the perpendicular drawn from the point ppCond to the line S-N.

Statistical processing of the results was carried out in the license package "Statistica 6.0". A direct stepwise regression analysis was used to construct the index models of the position of the central incisors of the lower and upper jaws. We have defined several conditions: 1) the final version of the regression polynomial must have a coefficient of determination (R^2) of at least 0.50, that is, the accuracy of the description of the trait being modeled at least 50.0%; 2) the value of the F-criterion is not less than 3.0, ie the contribution of the variable to the regression should be significant enough; 3) the number of free members included in the polynomial should be as low as

possible. In all cases, after the selection of the multiple regression equation, we analyzed the residuals, since emissions can significantly shift the results and lead to erroneous conclusions. When observations fell within ±3 standard deviations from the mean, we conducted repeated analyzes with and without emissions, in order to have confidence that they had no effect on the shift in the final results.

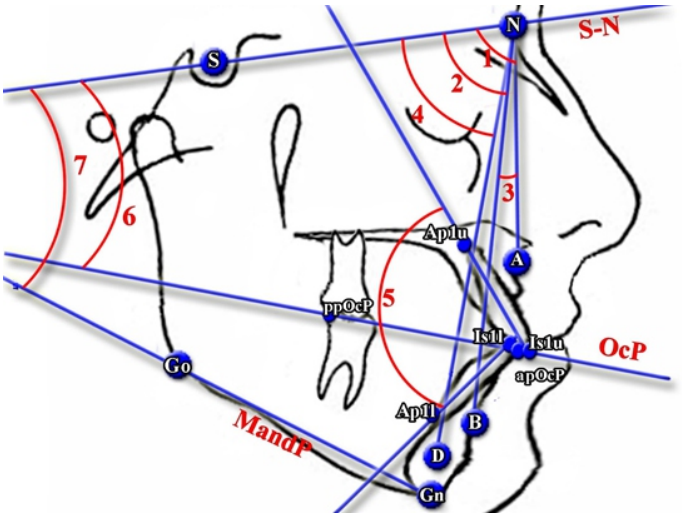

Figure 1: Cephalometric indicators according to Steiner: 1 – angle SNA; 2 – angle SNB; 3 – angle ANB; 4 – angle SND; 5 – inter-incisor angle II; 6 – angle SN_OcP; 7 – angle SN_GoGn.

Results

We studied the position indicators of the central incisors of the upper (Max1_NA, 1u_NA) and lower (Mand1_NB, 1l_NB) jaws for which Steiner developed values depending on the value of the inter-jaw angle ANB.[13] To evaluate the indicators, we used the percentile method, which is based on the percentage distribution of the frequencies of occurrence of the magnitude of the severity of a particular indicator. In the percentile method, the magnitude of the observed trait is considered average (typical) if it is within the 25th -75th percentile. The ANB angle values and the corresponding percentile values of the position characteristics of the central incisors for Ukrainian boys and girls, as well as the values developed by CC.Steiner, are presented in Tables 1-4.

As a result of the regression analysis, it was found that the boys dependent variable of the Max1_NA angle model by 70.6% depends on the total complex of the following characteristics included in the regression polynomial: angles ANB and SN_OcP (R^2=0.706). All the coefficients of this model have high reliability. The results of the ANOVA confirm the high significance (p<0.001) of the regression polynomial. The model has the form of the following linear equation: Max1_NA = 30.73 - 1.791*ANB - 0.399*SN_OcP.

In boys, the dependent variable of the Max1_SN angle model at 79.6% depends on the total complex of the following characteristics that are included in the regression polynomial: SND and ANB angles (R^2 = 0.796). All the coefficients of this model have high enough reliability. The results of the ANOVA confirm the high significance (p<0.001) of the regression polynomial. The model has the form of the following linear equation: Max1_SN = -10.75 + 1.488*SND - 0.638*ANB.

In boys, the dependent variable of the distance 1u_NA model 76.8% depends on the total complex of the following characteristics, which are included in the regression polynomial: ANB angle, distances S_L and S_E and angle SN_GoGn (R^2 = 0.768). All the coefficients of this model have high enough reliability. The results of the ANOVA confirm the high significance (p<0.001) of the regression polynomial. The model has the form of the following linear equation: 1u_NA = -4,396 - 0.486*ANB + 0.167*SE + 0.084*SL + 0.086*SN_GoGn.

Table 1: The value of the angle of inclination of the central axis of the upper central incisor relative to the line N-A (MAX1_NA), depending on the magnitude of the ANB angle in Ukrainian boys and girls and by Steiner.

Angle ANB (degrees)	The magnitude of the angle Max1_NA (degrees)						
	Ukrainian boys			Steiner[13]	Ukrainian girls		
	n	25,000th	75,000th		n	25,000th	75,000th
-2					4	2.2	27.9
-1				25	3	25.8	35.4
0	7	22.0	28.5	24	5	21.0	27.9
1	5	20.7	25.5	23	12	19.0	25.6
2	4	21.0	28.4	22	15	18.1	22.9
3	6	17.2	21.9	21	6	21.7	22.3
4	7	17.0	20.5	20	4	13.1	19.1
5	6	14.5	16.9	19	3	11.3	24.9

Notes: here and in the following tables, n – number of people; 25,000th and 75,000th – percentile limits; horizontally, the values for the angle ANB 2° are indicated, which is considered the norm, and in the vertical direction, the values of the corresponding central incisors, that are recommended by CC.Steiner for the corresponding angle ANB values; yellow indicates the values of indicators for Ukrainian boys and girls, which are significantly different from those proposed by CC.Steiner.

In boys, the dependent variable of the Mand1_NB angle model at 54.2% depends on the total set of characteristics included in the regression polynomial: ANB and SN_OcP angles and the Pog_NB distance (R^2 = 0.542). All the coefficients of this model have high enough reliability. The results of the ANOVA confirm the high significance (p<0.001) of the regression polynomial. The model has the form of the following linear

Table 2: The value of the location of the crown of the upper central incisor to the line N-A (1u_NA), depending on the size of the angle ANB in Ukrainian boys and girls and by Steiner.

Angle ANB (degrees)	The magnitude of the distance 1u_NA (mm)						
	Ukrainian boys			Steiner[13]	Ukrainian girls		
	n	25,000th	75,000th		n	25,000th	75,000th
-2				8	4	5.5	8.0
-1				7	3	6.0	8.0
0	7	5.0	6.0	6	5	5.0	7.0
1	5	4.0	5.0	5	12	4.0	7.0
2	4	5.0	8.5	4	15	4.0	5.0
3	6	3.0	5.0	3	6	4.0	5.0
4	7	4.0	5.0	2	4	2.5	4.5
5	6	3.0	3.0	1	3	2.0	5.0

Table 3: The value of the angle of inclination of the central axis of the lower central incisor relative to the line N-B (Mand1_NB), depending on the magnitude of the ANB angle in Ukrainian boys and girls and by Steiner.

Angle ANB (degrees)	The magnitude of the angle Mand1_NB (degrees)						
	Ukrainian boys			Steiner[13]	Ukrainian girls		
	n	25,000th	75,000th		n	25,000th	75,000th
-2					4	14.7	20.5
-1				22	3	16.9	23.8
0	7	14.5	25.7	23	5	17.0	22.6
1	5	17.0	23.5	24	12	19.7	27.4
2	4	23.6	27.9	25	15	22.1	25.2
3	6	22.2	29.1	26	6	21.1	29.5
4	7	22.4	31.1	27	4	27.6	33.8
5	6	26.1	28.7	28	3	28.4	34.2

equation: Mand1_NB = 26.90 + 1.548*ANB - 0.363*SN_OcP - 0.621*Pog_NB.

In boys, for 1l_NB the value is $R^2 = 0.459$ (less than 0.5), ie the accuracy of the description of the trait is negligible.

In girls, the dependent variable of the Max1_NA angle model is 54.2% dependent on the total set of characteristics included in the regression polynomial: ANB angle and Pog_NB distance ($R^2 = 0.542$). All the coefficients of this model have high reliability. The results of the ANOVA confirm the high significance ($p<0.001$) of the regression polynomial. The model has the form of the following linear equation: Max1_NA = 27.71 - 2.036*ANB - 0.953*Pog_NB.

In girls, the dependent variable of the Max1_SN angle of 52.2% depends on the total set of characteristics included in the regression polynomial: the SNA angle, the Pog_NB distance, and the SND angle ($R^2 = 0.522$). All the coefficients of this model have high enough reliability. The results of the ANOVA confirm the high significance ($p<0.001$) of the regression polynomial. The model has the form of the following linear equation: Max1_SN = 36.14 - 0.979*SNA - 1.712*Pog_NB + 1.949*SND.

In girls, the dependent variable of the 1u_NA distance model is 50.3% dependent on the total set of characteristics included in the regression polynomial: ANB angle and Pog_NB distance ($R^2 = 0.503$). All the coefficients of this model have high reliability. The results of the ANOVA confirm the high significance ($p<0.001$) of the regression polynomial. The model has the form of the following linear equation: 1u_NA = 6.859 - 0.660*ANB - 0.306*Pog_NB.

In girls, the dependent variable of the Mand1_NB angle model at 62.2% depends on the total set of characteristics included in the regression polynomial: ANB angle, Pog_NB distance, SNA angle, and S_L distance ($R^2 = 0.622$). All the coefficients of this model have high reliability. The results of the ANOVA confirm the high significance ($p<0.001$) of the regression polynomial. The model has the form of the following linear equation: Mand1_NB = 76.61 + 2.424*ANB - 2.064*Pog_NB - 0.816*SNA + 0.282*SL.

For indicator 1l_NB, the value of the coefficient of determination, as in boys is less than 0.5 ($R^2 = 0.445$), I.e. the accuracy of the description of the sign is negligible.

Table 4: The value of the location of the crown of the lower central incisor to the line N-B (1l_NB), depending on the size of the angle ANB in Ukrainian boys and girls and by Steiner.

Angle ANB (degrees)	The magnitude of the distance 1l_NB (mm)						
	Ukrainian boys			Steiner[13]	Ukrainian girls		
	n	25,000th	75,000th		N	25,000th	75,000th
-2				3.0	4	1.0	3.0
-1				3.25	3	3.0	5.0
0	7	3.0	4.0	3.5	5	2.0	4.0
1	5	3.0	4.0	3.75	12	3.0	5.5
2	4	5.0	7.0	4.0	15	3.0	5.0
3	6	3.0	7.0	4.25	6	4.0	5.0
4	7	5.0	5.0	4.5	4	3.5	6.5
5	6	5.0	6.0	4.75	3	5.0	9.0

Discussion

Directly close to forensic dentistry scientific discipline is forensic anthropology, which studies physical anthropology to identify individuals. Particularly noteworthy are works performed under the guidance of the anthropologist Gunas IV. in the field of both forensic anthropology[14] and forensic dentistry in the population of Podillia region of Ukraine.[15-17]

During the work with 243 boys and girls, with different forms of head and face who were residents of Podillia region of Ukraine, Gunas I. with co-authors[15] found the boundary percentile scope values of transversal characteristics of the dental arch:. In girls differences were found in the transversal dimensions of the lower and upper jaws, in the distribution of the type of face and shape of the head; while in boys such statistically significant differences were not found.

In another work performed by Marchenko et al. on the same population it was found that in mesocephals majority values of length of the teeth, root of medial and lateral incisors in the upper and lower jaws are significantly higher compared to brachycephals.[16]

18 reliable regression mathematical models were built for Ukrainian mesocephal girls to construct correct dental arch shape depending on the features of cephalometric and odontometric parameters. In 61.2% such models included tooth sizes and in 38.8% cephalometric indicators.[17]

Comparing the percentile span of the indexes of the position of the central incisors of the upper (Max1_NA, 1u_NA) and lower (Mand1_NB, 1l_NB) jaws, depending on the value of the ANB angle in Ukrainian boys and girls with the results provided by CC.Steiner,[13] we established a number of differences. Thus, the values of the Max1_NA angle in Ukrainian boys have smaller values (14.5-16.9°) than those of CC.Steiner (19°) with an angle ANB 5°; and girls have smaller values (13.1-19.1°) than according to CC.Steiner (20°) at ANB angle of 4°. The values of 1u_NA in Ukrainian boys are greater (5.0-8.5 mm, 4.0-5.0 mm and 3.0-3.0 mm) than those according to CC.Steiner (4 mm, 2 mm and 1 mm) when the angle ANB is 2°, 4° and 5°, respectively; and girls have higher values (4.0-5.0 mm, 2.5-4.5 mm and 2.0-5.0 mm) than according to CC.Steiner (3 mm, 2 mm and 1 mm) in magnitude ANB angles of 3°, 4° and 5°. The values of the Mand1_NB angle in Ukrainian boys are smaller (17.0-23.5°) than those according to CC.Steiner (24°) at an ANB angle of 1°; and girls have smaller values (17.0-22.6°) than those according to CC.Steiner (23°) at an angle ANB of 0°. The values of 1l_NA in Ukrainian boys have higher values (5.0-7.0 mm, 5.0-5.0 mm and 5.0-6.0 mm) than according to Steiner (4 mm, 4.5 mm and 4.75 mm) at an angle ANB of 2°, 4° and 5°, respectively; and girls have higher values (5.0-9.0 mm) than according to CC.Steiner (4.75 mm) at ANB angle of 5°.

Thus, with the exception of angle location of lower incisors (Mand1_NB angle), most differences in the characteristics of the position of the central incisors, both for Ukrainian boys and for Ukrainian girls, are observed at ANB values greater than 2°, that is, characteristic of the more distal location of the mandible.

The analysis of the regression models we developed showed that in determining the position of the central incisors of the lower and upper jaws in boys, the models include 100% of the angle ANB and 50% of the angle SN_OcP. For girls, models have 100% Pog_NB distance and 75% ANB angle. Therefore, the recommendation of CC.Steiner that the importance of taking into account the magnitude of the ANB angle and the distance Pog_NB in determining the position of the central incisors of the lower and upper jaws, found almost complete confirmation only in Ukrainian girls. In the Ukrainian boys, according to the recommendations of CC.Steiner, only the importance of the ANB angle value was confirmed.

Also interesting was the fact that the Ukrainian boys and girls regression models of distance 1l_NB had a low accuracy of description of the trait (R^2<0.5). This indicates the natural variability of this indicator independent of other indicators considered within the method of CC.Steiner.

Thus, in small steps, a strong theoretical anthropometric and odontometric base is formed, which serves as a reliable foundation for building a forensic dental service. One of the important bricks of this process is the method of analysis of lateral teleroentgenograms by the method of CC.Steiner for the Ukrainian population and development of mathematical models for determining the indexes of the position of the teeth of the upper and lower jaws.

Conclusions

Established ethnic differences in the characteristics of the position of the central incisors, depending on the size of the angle ANB – most differences for Ukrainian boys and girls from the values proposed by CC.Steiner observed with a more distal location of the mandible. The results of the regression analysis confirm the overall nature of the relationship of the main diagnostic parameters proposed by CC.Steiner. However, for more accurate prognostic purposes, it is better to use tailored ethnic and sex data. Mathematical models for determining the position of the central incisors of the lower and upper jaws, developed for Ukrainian boys and girls, can be used for forensic dental identification. Similar type of study is recommended for Indian population also to have more ethnic database

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