Modification of Dental Age Estimation Technique among Children from Transcarpathian Region

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Abstract

Despite development of new methodological approaches there is still a problem of implementation various methods of age estimation at the different geographical regions due to the polyethnicity factor of population, as it is represented at the Transcarpathian region of Ukraine. Objective of research was to to modify and experimentally prove the efficiency of age estimation techniques for children and adolescents adapted to the specific polyethical conditions of Transcarpathian region. A sample of 69 digital OPGs from the base of University Dental Clinic (Uzhhorod National University, Uzhhorod, Ukraine) of patients aged from 6 to 15 years was used for the research. Inclusion criteria for further analysis include next parameters: absence of congenital disorders of the teeth-jaw system, no fact of premature birth, absence of hypodontia or primary adentia. These parameters were determined by the analysis of medical records of patients whose images were initially selected for research. Age estimation was provided by Demirjian and Haavikko methods. Regression analysis and principles of determination search were used for providing higher correlation between results obtained by Haavikko method and summed maturing score. Due to results of Bland and Altman plot analysis it was found that the bias between chronological age and age estimated with correction formula was 0,03245 with value of standard deviation equal to 0,118. Agreement limits between chronological age and age estimated with correction formula were next: lower agreement limit -0,2134, upper agreement limit 0,2453, lower agreement limit-95%CL -0,2865, lower agreement limit+95%CL -0,1187, upper agreement limit-95%CL 0,1906, lower agreement limit+95%CL 0,2969.

The outcome of this research provides evidence for possibility of efficient modification of methods used for dental age estimation.

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Introduction

Dental status represents the set of reliable identification criteria that could be widely used in the practice of complex forensic examination and expert forensic evaluation[1,2,3,4]. Parameter of dental status (tooth structure, mandible bone morphology, anthropometric and anthropological features of facial skeleton) are the least variable and probably the most accurate criterion for providing process of age evaluation, since aging processes affects dentin, enamel, cementum and pulp structures in specific independent way, opposed to all other anatomical and functional systems of the body that are vulnerable to the effects of various pathologies, degeneration processes, congenital, structural and functional defects and constitution deformations[1,3,6,7]. Basically, age authentication based on the analysis of the skeletal elements, development and formation of which have specific age-related features, or taphonomical processes in those structures develops quite slow and with stated periodicity in order to be used as a reliable indicator of age identification criteria[8,9,10,11]. Despite progress in the field of forensic dental identification in Ukraine since 2013, when Ukraine Association of Forensic Odontology (UAFO) became a member of

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IOFOS, there is insufficient systematization of existing methods for determining the age of a person by dental status and methods to assess the reliability of those results obtained in different age groups among Ukrainian populations. Problem also exist in the implementation of various methodological approaches of age estimation at the different geographical regions due to the polyethnicity, as it is represented the most at the Transcarpathian region of Ukraine. Considering all this information we can summarize that there is a need to develop modified approach for evaluation age criterion among children of Transcarpathian region taking into account the historically and geographically formed multi-ethnic composition of the population and differentiation in time-based tooth formation and eruption process.

The present research aims to modify and experimentally prove the efficiency of age estimation techniques for children and adolescents adapted to the specifical polyethical conditions of Transcarpathian region.

Materials and methods

The study included the primary process of selection 118 panoramic x-rays results (digital OPGs, Planmeca) from the base of University Dental Clinic (Uzhhorod National University, Uzhhorod, Ukraine) of patients aged from 6 to 15 years. All OPGs were obtained from the base formed during the previous treatment planning of dental patients without providing new OPGs for this research. Inclusion criteria for further analysis include next parameters: absence of congenital disorders of the teeth-jaw system, no fact of premature birth, absence of hypodontia or primary adentia. These parameters were determined by the analysis of medical records of patients whose images were initially selected for research. Due to the inclusion criteria the sample of OPGs was reduced to 69 pieces and categorized in specific age groups from 6 to 15 years. Parents of children whose OPG were chosen for the research were informed with conditions and rules of the research methodology and signed and agreement form to use OPG as study material. All orthopantomograms went through the process of previous anonymization and further encoding of initial date of birth in order to avoid errors during the evaluation stages of teeth development. Thus, the researchers did

not know the source parameter of patients age during the analytical stage of research, and were informed about those age data only during the comparison of chronological and dental age indicators.

Tooth-staging process was carried out by two approaches provided by Demirjian and Haavikko methods[12,13,14,15]. Demirjian's method was implemented due to the original protocol proposed by Demirjian and Goldstein, in which the degree of tooth development is measured according to the table data, after which all numerical outcomes are added to obtain a total parameter of total maturity score. Haavikko's method was implemented by original proposal algorithm firstly described by the author. 15 dental X-ray panoramic results were used as randomly chosen sample to evaluate the inter- and intra-rater agreement in tooth staging process due to the principles of Demirjian and Haavikko methods. The degree of agreement was calculated using Cohen's Kappa and assessed according to the categories suggested by Landis and Koch, as previously was described in the research of Roberts G.J. et al (2008)[17]. Statistical analysis was carried out using criteria of correlation (Pearson coefficient), analysis of covariance (ANCOVA) and p-value estimation for Pearson's r. Comparing of methods of age estimation was provided by Bland-Altman plot, which also helped to estimate bias and agreements limits.

Results

The Kappa value for intra-rater agreement for examiner 1 was 0,87112, for examiner 2 it was 0,81284 and for inter-rater agreement between examiner 1 and examiner 2 was 0.79424 (substantial). During the evaluation of differences between results of Demirjian's and Haavikko's method and chronological age it was found that the mean deviation of Demirjian method is 0,37 (overestimation in 96,6% of cases) and mean deviation of Haavikko's method is 0,51 (underestimation in 100% cases). But during the ANCOVA-analysis it was found that summed maturity score presents symmetrical positive covariation not only with Demirjian's age estimation results, but also with Haavikko's age estimation results. Such fact provide statistical bases to found out the correlation Pearson's coefficient between summed maturity score and

obtained results of dental age estimation techniques: r=0,83 (p<0,05) for results produced by Demirjian's method, and r=0,67 (p<0,05) for results produced by Haavikko's method (Table 1).

Age group	Summed maturity score (total), M±m	
	Girls	Boys
6 years	59,81±2,18	55,16±2,23
7 years	73,42±2,09	64,45±2,18
8 years	81,05±2,02	78,72±2,14
9 years	89,67±2,08	82,16±2,08
10 years	90,15±1,99	85,95±2,11
11 years	91,11±1,97	89,84±2,01
12 years	92,98±1,91	91,14±1,92
13 years	93,56±1,85	93,48±1,87
14 years	97,11±1,81	95,16±1,87
15 years	99,12±1,80	97,86±1,79

Table 1. Parameters of summed maturity score.

Using regression analysis and principles of determination search we found regression formula for providing higher correlation between results obtained by Haavikko method and summed maturing score. Further correction formula can be presented in simple way:

Correction formula for boys = ((Result estimated by Haavikko method+Result estimated by Demirjian method)/2,107)*1,037;
Correction formula for girls = ((Result estimated by Haavikko method+Result estimated by Demirjian method)/1,974)*1,141.

Age group	Dental age by Haavikko	Dental age by Demirjian	Chronological age	Dental age by correction formula
6	5,29±0,22	6,77±0,29	6,17	6,31±0,39
7	6,16±0,29	7,61±0,36	7,45	7,16±0,88
8	7,38±0,34	9,09±0,27	8,23	8,37±0,39
9	8,34±0,18	9,49±0,21	9,08	9,33±0,95
10	9,13±0,25	10,84±0,31	10,12	10,17±0,64
11	10,28±0,29	11,71±0,29	11,16	11,25±0,79
12	11,31±0,32	12,89±0,37	12,56	12,47±0,45
13	13,06±0,35	14,18±0,26	13,85	14,05±0,95
14	13,720,31	14,79±0,22	14,55	14,85±0,26
15	14,41±0,21	15,63±0,24	15,3	15,49±05

Table 2. Results of age estimation by different technique among boys.

Due to results of Bland and Altman plot analysis it was found that the bias between chronological age and age estimated with correction formula was 0,03245 with value of

standard deviation equal to 0,118 (Table 2, Table 3). Agreement limits between chronological age and age estimated with correction formula were next: lower agreement limit -0,2134, upper agreement limit 0,2453, lower agreement limit-95%CL -0,2865, lower agreement limit+95%CL -0,1187, upper agreement limit-95%CL 0,1906, lower agreement limit+95%CL 0,2969.

Age group	Dental age by Haavikko	Dental age by Demirjian	Chronological age	Dental age by correction formula
6	5,55±0,29	6,44±0,34	6,58	6,48±0,42
7	6,38±0,24	7,72±0,38	7,23	7,25±0,18
8	8,24±0,32	8,51±0,26	8,81	8,97±0,89
9	8,12±0,36	9,42±0,22	9,25	9,17±0,85
10	9,95±0,27	10,47±0,35	10,41	10,61±0,51
11	10,86±0,35	11,43±0,31	11,32	11,60±0,49
12	11,86±0,32	12,78±0,18	12,56	12,63±0,51
13	13,19±0,20	14,11±0,27	13,89	14,07±0,94
14	14,03±0,19	14,76±0,33	14,42	14,72±0,58
15	14,21±0,25	15,58±0,19	15,11	15,23±0,08

Table 3. Results of age estimation by different technique among girls.

Disscussion

Dental age estimation by the OPG analysis remains one of the few minimally invasive technique used in forensic practice. Such method provides reliable results not only among adults, but also among children and adolescent population[8,10,13]. Previous researches showed the possibility to modified classical approach of age estimation method with correction coefficient to provide the most accurate results in specific research group or even among specific population[12,14,15,16,17].

Establishment of Forensic Odontology in Ukraine arguments the need to search adapted technique and develop new methods, modified due to the national needs in conditions of permanent anti-terroristic operation and considering the transition localization of Ukraine between Asia and European Union. Primary tasks of forensic age estimation by dental status due to the methodological development in Ukraine could be summarized in next objectives:
1. Verification of most reliable methods for age estimation and assess the reliability of the results obtained by such methods.
2. Conduction the comparative assessment of method for tooth development staging to provide efficient age estimation process among children and adolescents.

3. Development of new mathematical algorithm for calculating age parameters to improve the reliability of the results and minimize the levels of absolute and relative errors among specific demographical groups.

4. Development of semi-automatical forms for providing age estimation process by dental status. Present research helped to develop adapted algorithm of age estimation by dental status among children and adolescents at Transcarpathian region. Specifics of Transcarpathian region based on its geographical position on the verge of the border with Slovakia, Hungary, Romania and Poland, and heterogeneous population at this territory was formed historically through the last century. Actual population of Transcarpathian region due to the demographical information consist of next groups: Ukrainian - 80.5%, Hungarians - 12.1% Romanians - 2.6%, Russians - 2.5%, Roma - 1.1%, Slovaks - 0.5%, Germans - 0,3%, Jews - 0.05%. Taking into account continuing assimilation processes it could be noted that standard age estimation techniques due to factors mentioned above will not provide accurate numerical results, and the time-based stages of tooth formation are slightly changed comparing to the overall population of central Ukrainian region. Geopolitical uniqueness of Transcarpathian region is also argumented by its transient territory between European Union and refugees from Asia crossing border in Ukraine. In such cases, children lining in refugee camps sometimes have no relevant documents confirming the identity of the person, so evaluation of age parameter is critical for the formation of definitive identification profile. Age parameter is also an important criterion for argumenting criminal responsibility of children and adolescents, since such parameters differ in Ukraine and in the EU.

Proposed simplified method of age estimation represented by optimized formula was based on statistical analysis provided on the results obtained during the use of original approaches by Demirjian and Haavikko. Based on positive symmetrical covariation of summed maturity score with both groups of results we were able to provide correction coefficients for elevation correlation coefficient between two set of numerical data. Such proposal helped to minimize the level of relative mistake in all age groups and provided the higher accuracy of final

results on 21,7%, although this algorithm was not yet approbated on other research groups and so far could be recommended as effective only among specific population of children and adolescents of Transcarpathian region. During the analysis we have also noted the lowering of absolute error level at the age groups of 13-15 years compare to other age groups. Such tendency can be explained by more accurate grading of tooth development stages by forensic experts that took part in the research. The final stages of tooth development than can be noted at 13-15 years are one that can be most objectively interpreted by researches.

Conclusions

The outcome of this research provides evidence for possibility of efficient modification of methods used for dental age estimation. Even in the conditions of polyethnicity it is possible to provide statistically argumented approach that can minimize level of absolute mistake in specific age groups. The results were based on data obtained during statistical analysis and mathematical processing that guarantee accuracy of outcome numerical interpretation. The perspective of research aim to implement proposed algorithm in automatic form for development of efficient computer program and its future use in daily forensic practice.

Declaration of interest

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