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Demirjian's dental age estimation accuracy among Ukrainian Transcarpathian children sample: pilot study

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Abstract

Background. Number of forensic methods have been proposed for dental age estimation, while parameter of dental age itself is demonstrating a high level of correspondence with chronological age. Analysis of available literature revealed deficiency of studies regarding applicability of using Demirjian's age estimation technique among Ukrainian samples for forensic purpose.

Objective. To evaluate accuracy of original Demirjian's dental age estimation method among sample of Ukrainian Transcarpathian children.

Materials and Methods. Study was organized as retrospective by the design based on the analysis of 276 digital panoramic X-ray images obtained from the patients of University Dental Clinic aged 6.0-15.99 years old. Dental age estimation was held by the originally proposed Demirjian's technique.

Results. Dental age estimation using Demirjian's technique provoked overestimation effect on 0.43 years among patients aged 6.0-6.99 years, on 0.49 years among patients aged 7.0-7.99 years, on 0.47 years among patients aged 8.0-8.99 years, on 0.55 years among patients aged 9.0-9.99 years, on 0.51 years among patients aged 10.0-10.99 years, on 0.55 years among patients aged 11.0-11.99 years, on 0.44 years among patients aged 12.0-12.99 years, on 0.45 years among patients aged 13.0-13.99 years, on 0.54 years among patients aged 14.0-14.99 years, on 0.58 years among patients aged 15.0-15.99 years.

Conclusion. Demirjian's dental age estimation technique may be used for forensic purposes among population of children from Ukrainian Transcarpathia, if accuracy of other available dental age estimation methods would not be validated till the moment of needed forensic investigation.

Introduction

Age estimation represents an important aspect of forensic practice, which could be used during both ante-mortem and post-mortem person's identification [1, 2, 3]. Procedure of age estimation for forensic purposes should be provided in compliance with international guidelines, while such developed by different societies and national authorities need "higher homogenization and standardization" [4]. Cases of criminal responsibility evaluation and asylum status verification are the most widely associated with age estimation need among living, while parameter of age may be assessed using social services appraisement, psychological rating interview, analysis of anthropometric features, examination of sexual maturity features and survey of skeleton and dental status [1, 2, 3, 4, 5, 6]. The latter one has approved to be reliable criteria for age estimation while being used in combination with other methods, or in single mode use if implementation of other methods is restricted [4, 5, 6].

Number of forensic methods have been proposed for dental age estimation, while parameter of dental age itself is demonstrating a high level of correspondence with chronological age [5, 6, 7, 8]. Such correspondence is based on the specific interrelations between dental status changes during organism growth and development, that is why dental age estimation among children remains one of the most valuable instruments in forensic practice [5, 6, 7, 8].

One of the most commonly used method for dental age estimation among children was originally developed by Demirjian et al. in 1973, which have been widely approbated among different populational samples [7, 8, 9, 10, 11, 12]. Nevertheless, analysis of available literature revealed deficiency of studies regarding applicability of using Demirjian's age estimation technique among Ukrainian sample for forensic purpose. Considering that null hypothesis was formulated as follows: original Demirjian's dental age estimation method is not applicable for sample of Ukrainian Transcarpathian children due to the potentially low accuracy of obtained results.

Objective

To evaluate accuracy of original Demirjian's dental age estimation method among sample of Ukrainian Transcarpathian children.

Materials and Methods

Study Design

Study was organized as retrospective by the design based on the analysis of digital panoramic X-ray images/orthopantomograms (OPG) obtained from the patients of University Dental Clinic (Uzhhorod National University, Ukraine) aged 6.0-15.99 years old. Primary images of patients, who have undergone procedure of panoramic radiography due to the treatment or diagnostic needs during 2015-2019, and corresponded to the above-mentioned age range were collected by the radiologist of University Dental Clinic, who have further anonymized them prior to any analysis with only gender and date of birth available for the further processing of the data. Radiological specialist, who provided primary collection and anonymization of panoramic X-rays images, was not involved in any stage of further images processing with the aim of dental age estimation.

Quality of panoramic X-rays was analyzed regarding presence of graphical distortion in the projection of teeth, due to fact that such may restricts the possibility for adequate tooth development stage categorization as proposed by the Demirjian's technique. Images with critical graphical distortion that potentially may influence the interpretation of tooth developmental stage were excluded from the primary cohort. Age distribution was provided by the 0.99-year interval between the groups.

Demirjian's Dental Age Estimation Technique

Dental age (DA) estimation was held by the originally proposed Demirjian's technique [5, 9]. On each OPG developmental stage of seven left permanent teeth was evaluated due to the originally proposed eight categories A-H and following corresponding criteria (Figure 1 and Figure 2) [5, 9]. Values obtained for each tooth after transforming A-H stages into numerical coefficients were summed to verify dental maturity scores [5, 9]. Dental maturity scores were converted into specific age parameters using originally provided tables [5, 9].

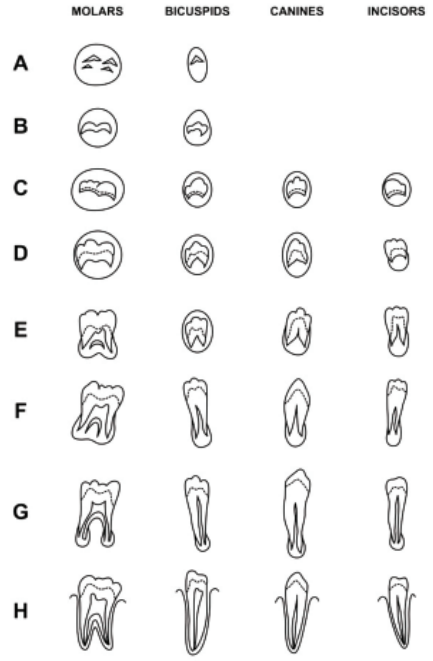

Figure 1. Schematic diagram of tooth developmental stages proposed by Demirjian A et al.

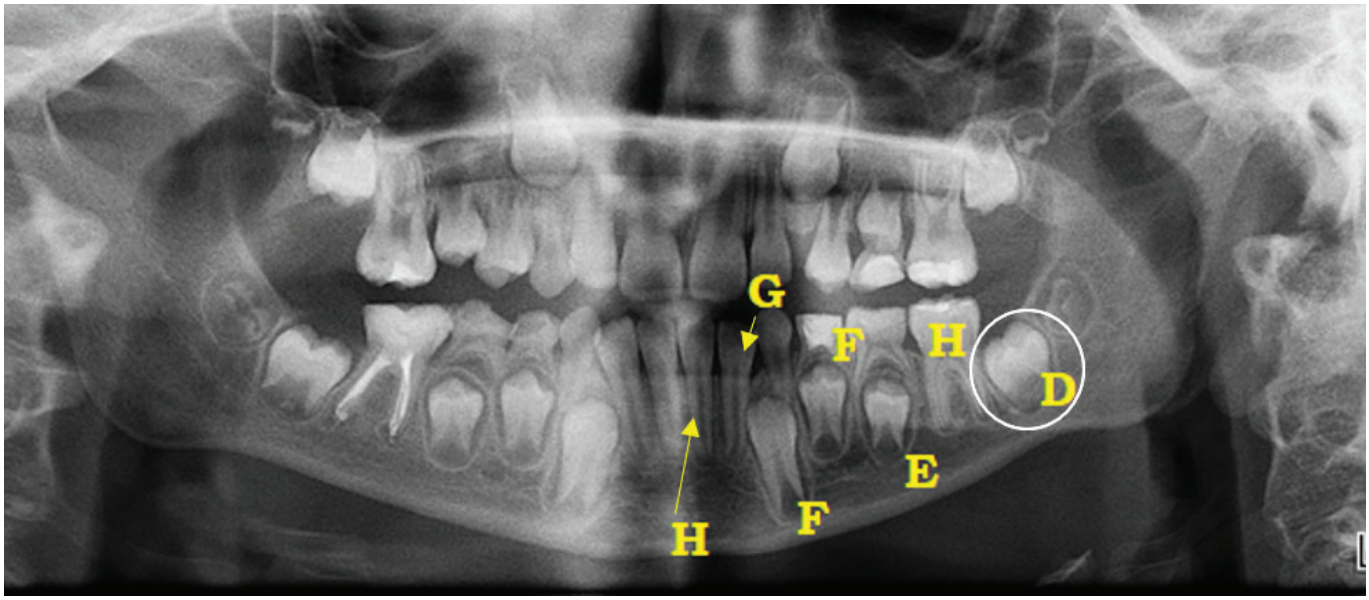

Figure 2. Example of applying Demirjian's tooth developmental stages to categorize the condition of seven left mandibular teeth as per originally proposed approach

Patient's chronological age (CA) was calculated by the formula: CA=Date of OPG obtainment-Date of birth, with its representation in decimals of year.

Statistical Analysis

Mean values and standard deviation (SD) were calculated for the dental age and chronological age of each age group. Mean difference between dental age and chronological age was evaluated with the use of mean error (ME = CA-DA) for each specific person, while positive ME was standing for underestimation of dental age compare to chronological one, and negative – for overestimation effect. Mean absolute error (MAE) as an average of all absolute errors within different age groups helped to quantify the magnitude of the discrepancy between dental and chronological age. Correlation between dental age estimated by Demirjian's approach and chronological age was assessed with the use of Pearson's r. Interrelations between dental age as independent variable and chronological age as arbitrary output was assessed by the linear regression method. Probability (p) was categorized as follows for all applicable tests: if $p \geq 0.05$ – non significant, if $p < 0.05$ – significant. Statistical analysis of variables was provided within Microsoft Excel 2019 software (Microsoft Office 2019, Microsoft Corp., USA) with the additional use of XLSTAT add-in (Addinsoft Inc., Long Island, NY, USA).

Ethical Aspects

Ethical approval for present study was granted by the Ethical Committee of Faculty of Dentistry, Uzhhorod National University (#16/2018 at 16/10/2018) as a part of ethical approval for complex dissertational thesis "Clinical and experimental argumentation for children and adolescents dental treatment approaches improvement using forensic dental methods". Ethical Committee confirmed that presented study by its design and realization comply with Helsinki Declaration regarding study of human beings, and assuring the anonymity of the study subjects.

Results

Overall 276 OPGs were analyzed, distribution of which presented in Table 1. Mean chronological age of patients within age group of 6.0-6.99 years was 6.53±0.24 years, within age group of 7.0-7.99 years – 7.53±0.29 years, within age group 8.0-8.99 years – 8.55±0.31 years, within age group 9.0-9.99 years – 9.54±0.28 years, within age group 10.0-10.99 years – 10.49±0.28 years, within age group 11.0-11.99 years – 11.57±0.27 years, within age group 12.0-12.99 years – 12.40±0.28 years, within age group 13.0-13.99 years – 13.43±0.29 years, within age group 14.0-14.99 years – 14.55±0.23 years, within age group 15.0-15.99 years – 15.47±0.25 years.

Dental age estimation using Demirjian's technique provoked overestimation effect on 0.43 years among patients aged 6.0-6.99 years, on 0.49 years among patients aged 7.0-7.99 years, on 0.47 years among patients aged 8.0-8.99 years, on 0.55 years among patients aged 9.0-9.99 years, on 0.51 years among patients aged 10.0-10.99 years, on 0.55 years among patients aged 11.0-11.99 years, on 0.44 years among patients aged 12.0-12.99 years, on 0.45 years among patients aged 13.0-13.99 years, on 0.54 years among patients aged 14.0-14.99 years, on 0.58 years among patients aged 15.0-15.99 years (Table 1).

Provided regression analysis given the obtained results of coefficient of determination (R2) has shown that within age group 6.0-6.99 years 77% of the variability of the chronological age could be explained by the explanatory variable (dental age), within age group of 7.0-7.99 years such parameter was equaled to 82%, within age group 8.0-8.99 years – to 87%, within age group 9.0-9.99 years – to 75%, within age group 10.0-10.99 years – to 72%, within age group 11.0-11.99 years – to 77%, within age group 12.0-12.99 years – to 69%, within age group 13.0-13.99 years – to 79%, within age group 14.0-14.99 years – to 83%, within age group 15.0-15.99 years – to 84% (Figure 3).

Table 1. Correspondence between chronological age and dental age estimated by original Demirjian's method

Age group	Approbation of Demirjian's age estimation technique						
	Number of patients	Chronological age	SD	Dental age	SD	MAE	Direction of ME
6.0 - 6.99	27	6.53	0.24	6.96	0.26	0.43	Overestimation
7.0-7.99	24	7.53	0.29	8.02	0.30	0.49	Overestimation
8.0-8.99	26	8.55	0.31	9.02	0.30	0.47	Overestimation
9.0-9.99	28	9.54	0.28	10.09	0.29	0.55	Overestimation
10.0-10.99	33	10.49	0.28	11.00	0.32	0.51	Overestimation
11.0-11.99	29	11.57	0.27	12.12	0.31	0.55	Overestimation
12.0-12.99	30	12.40	0.28	12.84	0.30	0.44	Overestimation
13.0-13.99	26	13.43	0.29	13.88	0.30	0.45	Overestimation
14.0-14.99	28	14.55	0.23	15.09	0.27	0.54	Overestimation
15.0-15.99	25	15.47	0.25	16.05	0.27	0.58	Overestimation

ME – mean error, **MAE** – mean absolute error

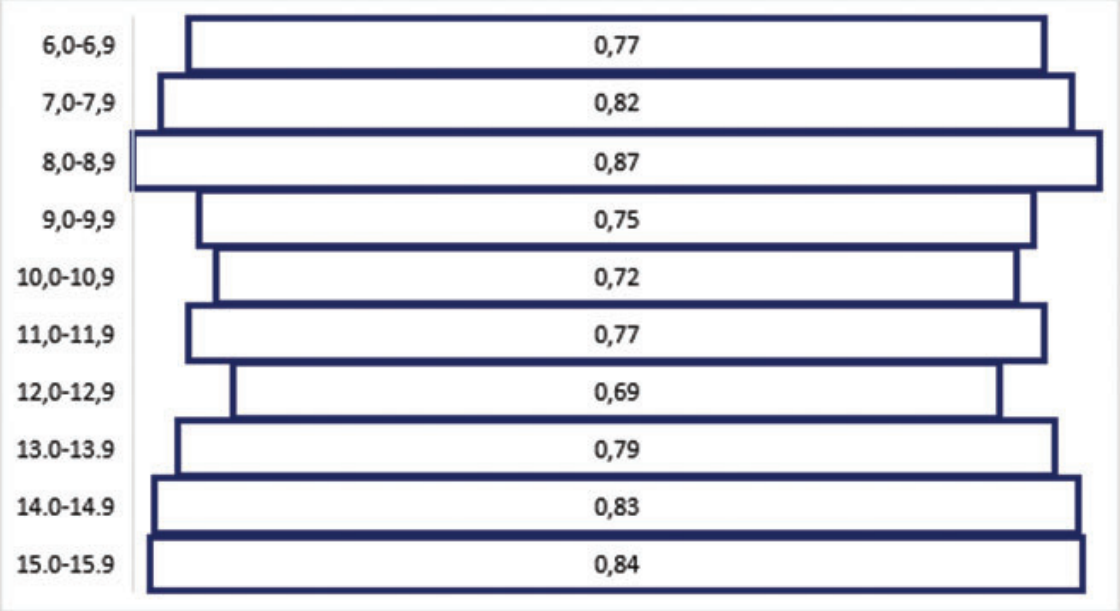

Figure 3. Coefficients of determination (R2) demonstrating which percentage of chronological age variability could be explained by the explanatory variable (dental age) at different age groups

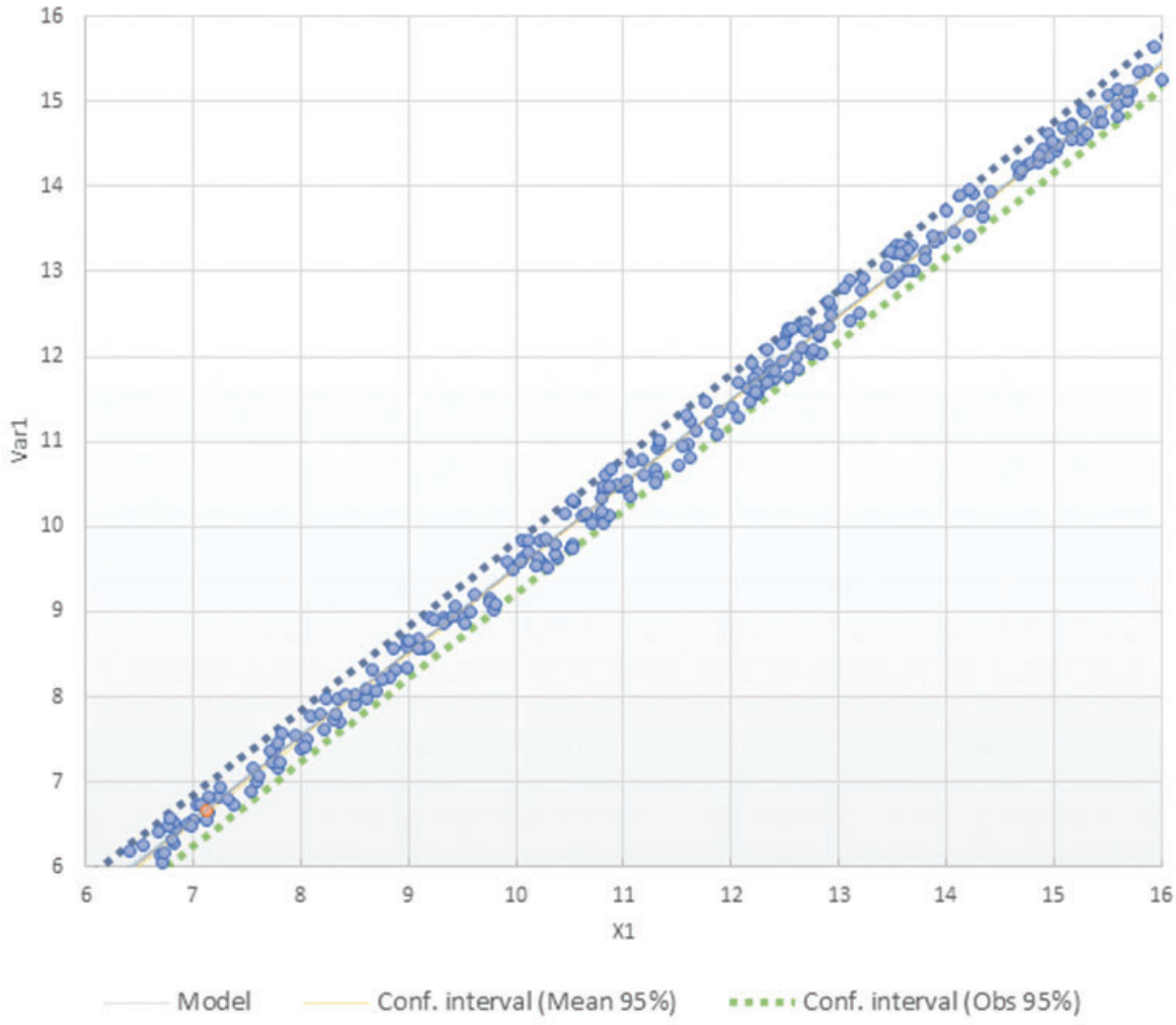

Figure 4. Linear regression of chronological age by dental age estimated with original Demirjian's technique

Considering regression analysis results, given the p-value of the F statistic computed in the ANOVA table, and given the significance level of 5%, the information brought by the dental age variables is significantly better than what a basic mean would bring for prediction of chronological age (Figure 4).

Discussion

Present study demonstrated applicability of Demirjian's age estimation technique for Transcarpathian Ukrainian children sample, even though in all analyzed cases among all age groups such approach caused overestimation effect of different ranges. Based on the obtained outcomes null hypothesis may be rejected.

Previously systematic review with accompanied meta-analyses verified that originally proposed French-Canadian data set of Demirjian for dental age estimation provoked overestimation effect regarding chronological age of the children by the mean of 0.65 years for female (in the range of -0.10-+2.82 years) and 0.60 years for males (in the range of -0.23-+3.04 years) [10]. Considering above mentioned results authors concluded that applicability of Demirjian's dental age estimation technique for different groups of global population should be interpreted with the caution while using it for forensic dental purposes [10]. In another systematic review provided among studies aimed at assessment of dental age estimation methods applied among Brazilian children the highest standardized mean difference equaled to 1.81 was noticed for Demirjian's age estimation technique [8]. Meta-analyses of published studies revealed that Demirjian's method characterized with weighted mean difference at the level of 0.62 for males and 0.72 for females [11]. Authors suggested that populational variations may be considered as confounder during the phase of converting maturity scores into dental ages [11]. Results obtained in our research is analogical to the outcomes in above-mentioned systematic reviews and meta-analyses, since in all studies Demirjian's dental age estimation method caused overestimation compare to chronological age. Overestimation in our study was quantitively lower than in reported systematic reviews among patients aged 6.0-13.99 years, which could be associated with relatively smaller size of study sample in present research. On the other hand, we have not provided stratification of results for male and female separately due to the pilot design of the study which was dedicated specifically to the assessment of Demirjian's method applicability for Ukrainian Transcarpathian children population, and because of that our mean absolute error may be lower than in systematic reviews. It is also should be kept in mind that systematic reviews present essence of aggregated data from several studies, which in turn could cause discrepancies of results presented in our study and such obtained during meta-analytical processing of previous ones.

In literature review of De Donno A. et al. Demirjian's methods was compared with Willems', Cameriere's, Nolla's, Smith's, Haavikko's and Chaillet's methods, during which it was found that Demirjian's approach characterized with overestimation effect among all studied populations, except Turkish and Chinese; while the smallest difference between dental age and chronological age after using Demirjian's method was noted among German sample [7]. Accuracy parameters of Demirjian's methods obtained in our study arithmetically similar to those reported for German sample in De Donno A. et al. literature review [7].

Approaches for Demirjian's method adaptation have been previously described in forensic dental literature [12, 13, 14, 15]. Ali. A.M. and colleagues proposed predication formulas based on provided logistic regression analysis, which may be considered as valuable modification for Demirjian's dental age estimation for children of Egyptian origin [12]. In our study we also used linear regression method to evaluate interrelations between chronological age and dental age estimated by Demirjian's method, which helped us to conclude that information brought by the dental age variables is significantly better than what a basic mean would bring for prediction of chronological age. After appropriate statistical processing such outcomes may be used to provide predication formulas for chronological age based on dental age calculated with Demirjian's method specifically for Ukrainian children sample.

Previously it was also proposed to use both Demirjian's and Haavikko's methods for dental age estimation among children from Transcarpathia by combining their results within unified equation to get more accurate outcome [13]. Obtained results demonstrated efficiency of such approach, but its realization was considered time-consuming.

Other studies described methods for adaptation of "maturity score-dental age conversion tables" for different populations, while further researches are needed to evaluate validity of such alternatives among targeted samples [14, 15, 16]. Nevertheless, it should be also taken into account that Jayaraman J. and Roberts D. raised the question regarding applicability of Demirjian's maturity data for dental age estimation, and pointed out the need to clarify statistical approach that has been used to derive maturity score [17].

Relevant improvements of dental age estimation focused also on using artificial intelligence functions for dental X-rays digital images analysis with the aim to provide automated categorization of tooth developmental stage [18, 19, 20].

Limitations of present study related with its retrospective design due to which panoramic X-ray images with data available only regarding date of patient's birth and gender were used for analysis. No origin-related information was gathered from the patients, while also their socio-economical status and features of living were not considered for analysis because of formulated design of study. Territory of Ukrainian Transcarpathia is a place with specific biogeochemical fluorine and iodine deficiency, which in turn could affect the prevalence of dental diseases and features of dental development among pediatric population. The latter may affect the compliance between the chronological age of children and maturity scores obtained for them due to the Demirjian's technique. Also, it should be noted that Ukrainian Transcarpathia associated with various populations demographics, including Hungarians, Romanians, Roma, Slovaks and others. Potentially these populational groups could be associated with need to develop different targeted maturity scores tables or reference sets of coefficients for each of them separately. Because of limited access to information caused by originally developed study design above-mentioned factors were not considered during analysis of dental age estimation results obtained after Demirjian's technique implementation. Another limitation of the study is associated with relatively small size of each age group, while in future studies we will consider recommendations for minimally needed enrollment of participant due to the number of examined features for each of them [2, 3]. Also, we have not provided stratification analysis separately for male and females due to the pilot design of study which was dedicated specifically to the assessment of Demirjian's method applicability for Transcarpathian children population.

Perspectives of future studies will be dedicated to the evaluation of Willems age estimation technique accuracy among the population of Ukrainian Transcarpathian children while also stratifying their affiliation to specific populational group. In the meta-analysis of published studies, it was revealed that Willems method, which was originally developed based on the Demirjian's method principles, provides more accurate results regarding age estimation [11]. Such effect may be caused by excluding phase of maturity scores-dental age conversion from Willems techniques, while providing direct conversion of tooth developmental stage into specific age coefficient. Another perspective of future studies includes development of population-specific standards of age estimation and reference data set for Ukrainian Transcarpathian children samples, which potentially could provide better outcome than universal approaches or such that has been developed for other populations.

Conclusion

Considering limitations of present study, it may be resumed that Demirjian's dental age estimation technique may be used for forensic purposes among population of children from Ukrainian Transcarpathia, if accuracy of other available dental age estimation methods would not be validated till the moment of needed forensic investigation. Original Demirjian's approach causing overestimation

effect in the range of 0.43-0.58 years among Transcarpathian children aged 6.0-15.99 years. Nevertheless, further research should be provided over larger study sample to evaluate not only the magnitude and direction of errors while comparing dental and chronological age, but also variability of such in different age groups while using Demirjian's age estimation technique.

Conflict of Interest

The author does not have any potential conflict of interests that may influence the decision to publish this article.

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Точність визначення дентального віку за методикою Demirjian серед вибірки дітей, які проживають на території Закарпаття: пілотне дослідження

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A – розробка концепції та дизайну дослідження, B – збір та або систематизація даних дослідження, C – аналіз та тлумачення даних дослідження, D – написання публікації, E – критичне доопрацювання тексту публікації, F- остаточне затвердження.

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Анотація

Вступ. Враховуючи що показник дентального віку характеризується високим рівнем узгодженості із фактичним хронологічним віком особи, для оцінки параметру стоматологічного віку було розроблено ряд судово-медичних методів. Проте проведений аналіз наявних літературних даних дозволив виявити дефіцит досліджень, присвячених оцінці ефективності застосування методики визначення дентального віку за Demirjian серед різних вибірок осіб на території України в ході проведення судово-медичних експертиз.

Мета. Оцінити точність оригінального методу визначення дентального віку за Demirjian серед вибірки дітей, які проживають на території Закарпаття.

Матеріали та методи. Дизайн дослідження передбачав ретроспективний аналіз 276 цифрових ортопантомограм пацієнтів Університетської стоматологічної клініки віком 6,0-15,99 років. Визначення показника дентального віку проводилося за оригінальною методикою Demirjian.

Результати. Визначення дентального віку за методикою Demirjian було пов'язано із ефектом завищення встановлених показників відносно фактичного хронологічного віку на 0,43 року серед пацієнтів віком 6,0-6,99 років, на 0,49 року серед пацієнтів віком 7,0-7,99 років, на 0,47 року серед пацієнтів віком 8,0-8,99 років, на 0,55 року серед пацієнтів віком 9,0-9,99 років, на 0,51 року серед пацієнтів 10,0-10,99 років, на 0,55 року серед пацієнтів 11,0-11,99 років, на 0,44 року серед пацієнтів 12,0-12,99 років, на 0,45 року серед пацієнтів 13,0-13,99 років, на 0,54 року серед пацієнтів віком 14,0-14,99 років, на 0,58 року серед пацієнтів віком 15,0-15,99 років.

Висновок. Методика визначення дентального віку за Demirjian при потребі може бути використана в ході судово-медичних експертиз, котрі передбачають залучення дітей, які проживають на території Закарпаття, якщо до моменту проведення необхідних судово-медичних досліджень не буде встановлено точності інших методів оцінки віку дітей за стоматологічним статусом.

Конфлікт інтересів
Автор не має потенційного конфлікту інтересів, який міг би вплинути на рішення про публікацію цієї статті.

Фінансування
Не було отримано жодного фінансування для допомоги в підготовці та проведенні цього дослідження, а також у підготовці цієї статті.

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