Journal of Forensic and Legal Medicine 20 (2013) 40–45

Contents lists available at SciVerse ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original communication

# Dental age estimation on Bosnian–Herzegovinian children aged 6–14 years: Evaluation of Chaillet's international maturity standards

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ARTICLE INFO

*Article history:*
Received 12 October 2011
Received in revised form
14 December 2011
Accepted 25 April 2012
Available online 19 May 2012

*Keywords:*
Forensic odontology
Chaillet's method
Dental age
Bosnia and Herzegovina
Polynomial function
International standards

ABSTRACT

*Background:* Dental age estimation in children plays an important role in forensic dentistry. The most commonly used method for age estimation was developed by Demirjian in 1973 on a French–Canadian sample. It generally overestimates dental age in many populations. International maturity standards were formed to obtain a predicted age with more confidence when ethnic origin was not available.
*Objectives:* The aim of this study was to evaluate the applicability of Chaillet's international scores in the dental age assessment on Bosnian Herzegovinian (BH) children.
*Methods:* Orthopantomograms of 1772 children, 980 girls and 792 boys aged 6.04–14.90 years, were assessed using Chaillet's international maturity tables and curves. The dental ages for both genders were compared to the chronological ages through a paired *t*-test.
*Results:* Mean overestimation using Chaillet's international maturity standards were 0.09 ± 0.83 for girls and 0.28 ± 0.90 for boys. The absolute accuracy of residuals between the dental and chronological age were 0.65 ± 0.52 years for girls (Median: 0.52 years) and 0.73 ± 0.60 years for boys (Median: 0.57 years).
*Conclusion:* The Polynomial compound formula was recommended to predict dental age with more accuracy for results of international maturity standards on BH children.


## 1. Introduction

Age estimation on living individuals and skeletal remains has importance in legal and forensic medicine, human anthropology and bioarchaeology. Forensic odontology encompasses a wide range of clinical, laboratorial, radiographic and other available methods for age estimation using teeth. The development and maturation of teeth in growing children brings two main approaches to assessing their age. These are the evaluation of clinical emergence in the mouth and the radiographic evaluation of the mineralization of crowns and roots of primary and permanent dentition.[1] The clinical emergence of both in deciduous and permanent teeth is affected by different local factors, including feeding habits, local trauma and the pathology of deciduous teeth. The mineralization and growth of crowns and roots is a continuous processes that goes on, until the closure of apices of teeth, and these are less affected by some local and systemic factors.[2] In order to quantify a continuous process from the first traces of cusps mineralization until root apex closure, many authors suggested a different number of radiographic stages, ranging from three stages suggested by Hunt and Gleiser,[3] sixteen stages suggested by Moorrees et al.,[4] twelve stages by Haavikko[5] to possibly 40 stages suggested by Nolla.[6] Additionally, a different number of teeth was used for radiographic evaluation; from only one tooth, being the lower first molar suggested by Hunt and Glasser[3] to the evaluation of all permanent teeth in both jaws, suggested by Nolla[6] and Haavikko.[5]

In 1973 Demirjian et al.[7] introduced a method based on the evaluation of seven permanent teeth from the left side of the lower jaw, excluding the third molar, by choosing one of eight

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doi:10.1016/j.jflm.2012.04.037

radiographic stages of crown and root mineralization. Each tooth is scored with appropriate points according to the relevant radiographic stage in order to quantify dental maturation. The sum of these points of all seven teeth presents a dental maturity score on a scale from 0 to 100, similarly to Tanner and Whitehouse hand and wrist maturity system.[7] Several papers showed a great variability of estimated age, generally an overestimation, compared to French–Canadian standards.[8] In order to obtain a predictable age with more confidence some authors suggested the adaptation of Demirjian's method including the polynomial or regression analysis or the creation of new dental developmental tables and curves.[9–15]

Ideally, age estimation in a specific population should be done by the usage of different methods provided by existing literature and practices as well as the development of new methods to ensure the application of the most adequate technique.[8] Previous studies on dental age using OPGs of BH children, showed an overestimation by Demirjian's and by Willems' methods. Haavikko's method underestimated for both genders and Cameriere method overestimated for girls and underestimated for boys.[16,17] Chaillet et al.[18] introduced adopted dental development tables and curves as a result of a study of radiographs from 8 countries using Demirjian's method in order to construct international dental age estimation standards when the ethnic origin is unknown. In conclusion, the aim of this study was to evaluate the accuracy of international maturity curves by Chaillet for age estimation in BH children.

## 2. Subjects and methods

### 2.1. Subjects

The study sample consisted of 1772 OPGs of Bosnian–Herzegovinian children, selected from a radiographic collection held by the University of Sarajevo Faculty of Stomatology and principal regional public dental institutions in Bosnia and Herzegovina in order to encompass Bosnians, Croats and Serbs who represent the major ethnic make up of the country. The Radiographs of 980 girls and 792 boys aged 6.04–14.90 years were dated from year 2000–2011 (Table 1).

Exclusion criteria for OPGs were: incomplete dental records including the absence of the recorded date of birth and date of radiograph, low quality panoramic radiographs, agenesis or extraction of permanent teeth from the lower jaw, recorded systematic diseases, premature birth and congenital anomalies. Patients' personal data were not collected except for the date of birth, date of radiograph and gender and their parents or guardians had signed an agreement with the dental institutions concerned that dental records and radiographs could only be used for research and educational purposes without the possibility of jeopardizing their confidentiality. The chronological age for each child was determined by the date of the radiograph and the date of birth after converting both to a decimal age according to Eveleth and Tanner.[19]

**Table 1**
Age and gender distribution of the sample of orthopantomograms.

| Age group | Girls | Boys | All |
|---|---|---|---|
| 6.00–6.99 | 30 | 31 | 61 |
| 7.00–7.99 | 81 | 50 | 131 |
| 8.00–8.99 | 126 | 103 | 229 |
| 9.00–9.99 | 213 | 153 | 366 |
| 10.00–10.99 | 139 | 135 | 274 |
| 11.00–11.99 | 162 | 136 | 298 |
| 12.00–12.99 | 138 | 103 | 241 |
| 13.00–13.99 | 67 | 57 | 124 |
| 14.00–14.99 | 24 | 24 | 48 |
| 6.00–14.99 | 980 | 792 | 1772 |

### 2.2. Method

The OPGs were photographed using a Kodak EasyShare Z812-IS Digital Camera. The digital images were stored and examined by using the Corel Draw software package (Corel Draw v.12.0, 2003, Corel Corporation, Ottawa, Canada). The developmental stages of seven permanent teeth, excluding the third molar, from the left side of the mandible were evaluated using an eight-grade scale marked with an alphabet (A–H) according to Demirjian's criteria.[7] Then, the dental age was calculated using international maturity tables and median curves from Chaillet et al., specific for girls and boys.[18]

### 2.3. Statistical analysis and data management

SPSS Statistics 17.0 for Windows (SPSS Inc., Chicago, IL) and MS Excel 2003 (Microsoft Office 2003, Microsoft, Redmond, WA) were used for all statistical analysis and data management.

The evaluation of mineralization stages was done by the first author. For intra-observer repeatability and inter-observer reproducibility 177 (10%) randomly selected OPGs were reexamined two months after examination by the first and the fourth author (EN). Kappa was used to measure repeatability of Demirjian's stages for each tooth.

The intra-observer repeatability and inter-observer reproducibility of dental age was tested with intra-class correlation coefficient (ICC).[20]

The difference between the chronological age between girls and boys was tested with independent samples *t*-test.

The correlations between dental age as a result of international maturity standards and the chronological age and coefficients of determination were verified by the linear regression analysis for girls and boys separately.

Analyses were made for each gender and age cohort (i.e. children between 10.00 and 10.99 years of age) would be included in the 10 years cohort and so on. The accuracy of the method was determined by mean difference between dental age and chronological age (DA–CA) or mean residual. Paired samples *t*-test was applied to assess the significances of the difference between dental age (DA) and chronological age (CA) for both genders and age cohort separately. Due to multiple testing, the exact probability for each evaluated difference is reported. Tests with a $P$ value less than 0.0025 can be considered significant according to Bonferroni correction.[21]

The absolute accuracy or prediction error, which reports only the time distance from true age, was calculated for both genders separately.

Different polynomial functions were explored in calculations of dental age as the dependent variable versus a maturity score as independent variable, for both genders separately, in order to increase the proportion of variance explained.

## 3. Results

The Kappa for repeatability of developing stages ranged from 0.75 to 0.89 for intra-observer repeatability and from 0.69 to 0.89 for inter-rater reproducibility (Table 2).

The estimated ICC (95% confidence intervals) for the calculated dental age were for intra-observer repeatability was 0.969 (0.958–0.977), and for inter-observer reproducibility was 0.961 (0.946–0.971). There was no statistically significant difference in the chronological age between girls and boys, $t$ (1770) = 0.751 ($P$ = 0.453). Strong linear correlation between the international