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Forensic Anthropology Population Data

Cameriere's third molar maturity index in assessing age of majority

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ABSTRACT

Estimation of chronological age of an individual is one of the main challenges in forensic science. Legally to be able to treat a person as a minor or an adult, it is necessary to determine whether their age of majority (if they are older or younger than 18, in most countries). Methods for estimating age are especially important when an individual in question lacks personal documents or other means of identification. As the dental age differs in various populations, the aim of this study was to evaluate applicability of third molar method for assessing age of majority in Croatia.

Cameriere's third molar maturity index (I_{3M}) value of 0.08, measured by the open apices of the teeth, was verified in sample of 1336 panoramic images aged between 14 and 23 years. Chronological age gradually decreased as I_{3M} increased in both genders. Males showed statistically significant advanced maturation when I_{3M} was between 0.0 and 0.3 value. The results indicate that the sensitivity of the test for 0.08 value was 84.3% (95%CI 80.6%, 87.5%) for females and 91.2% (95%CI 88.7%, 93.1) for males. Specificity was 95.4% (95%CI 92.5%, 97.5%) and 91.9% (95%CI 88.8%, 94.3%). The proportions of accurately classified males were 88.8% and that of females 91.5%. The estimated post-test probabilities, of individuals, in other word the probability that a Croatian individual with an $I_{3M} < 0.08$ is 18 years or older is 94.5% for females, and 96.5% for males.

With high accuracy, the third molar maturity index should be used as a determinant of the age of majority in Croatia.

1. Introduction

Estimation of the real age of individuals is one of the main challenges in forensic science. Most methods used today can be divided to either non-medical procedures that include personal check and identification documents, medical procedures that include physical and radiological examinations or those that are the combination of the two [1,2]. Study Group on Forensic Age Diagnostics (AGFAD) presented criteria for age estimation in living individuals and listed: physical examination and anthropometric measures, inspection of sexual maturation, radiological examination of left hand or computer tomography (CT) examination of the clavicle in cases when the hand skeletal development is completed, and dental examination with radiologic analyses of the dentition [3]. In line with AGFAD guidelines, an additional radiographic or CT examination of collar bones is recommended to evaluate the age of persons who are assumed to be at least 18 years old [2]. Estimation methods that involve hand and wrist bones are not suitable for adults because skeletal development of hand bones is completed by the age of 17 years in girls and 18 years in boys [4].

Croatian War for Independence, which lasted from 1991 to 1995, lead to a large number of persons still presumed missing, and

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caused particular challenges for experts in forensic odontology in identifying these victims [5–7]. Furthermore, many countries within the European Union and countries such as Norway or Switzerland, have been seeing a large influx of foreigners pursuing settlement or political asylum [8]. Croatia joined the European Union in 2013 and was identified as one of the preferred countries for immigration, transition and asylum seeking. One of the main questions in penal and criminal law and general legislation – in Croatia and other nations inside European Union – is whether the person is older or younger than 18 years, an adult or a minor. This is especially pertinent when an individual is without personal documents or other means of identification. Beside 18 years cut-off, there are several important ages cut-offs in Croatian legislation. Depending on the age, laws impose different misdemeanour and penalties. Persons younger than 14 years are considered children, persons aged 14–16 years are considered younger minors, persons aged 16–18 years are elder minors, persons aged 18–20 are consider younger adults, while those older than 21 years are considered adults [9]. The age limit of 15 years is important in criminal law with respect to offences of sexual abuse and exploitation of children and is a minimum required age for acquiring employment [9,10]. Dental examination methods on growing teeth are today either the evaluation of clinical emergence of teeth or the radiographic evaluation of the mineralization of crowns and roots of primary and permanent dentition [11,12]. Assessment of tooth mineralization can be done by: (1) applying methods which estimate the developmental stages of the target group of teeth, (2) measuring apices of dental roots with incomplete development, (3) using the atlas growth and teeth development index? [12–15]. Furthermore, assessment of regressive changes in primary and permanent teeth can also be used [16–22]. Age estimation by analysis of mineralization of permanent teeth, excluding third molars, is highly effective until the age of 13 years from the development of second molars [23,24]. Assessment of third molars is applied for those between 13 and 23 years of age [23,25–27]. Mincer et al. [28] studied third molars of American whites and blacks, aged 14–24, using Demirjian staging system (A–H), to estimate their chronological age. Cameriere at al. [29], for determining 18 years of age introduced a method based on the relationship between age and the third molar maturity index (I_{3M}), calculated by measuring the open apices of the third molar. Recent studies from Italy on 397 subjects aged between 13 and 22 years from Milan area another from Albania on 286 subjects aged between 15 and 22 years showed a very high percentage of correctly classified individuals and estimated post-test probability [30,31]. As no studies so far have evaluated the I_{3M} method on individuals from the Republic of Croatia, it was our goal to do so on a young adult Croatian sample.

2. Materials and methods

2.1. Sample

Panoramic radiographs (OPTs) of 1416 Croatian children and adolescents between 14 and 23 years of age, without recorded developmental abnormalities in either dental or medical records, were evaluated. The sample was randomly selected from the patients attending the Split-Dalmatia County Community Health Centre, and Dental Clinic and Radiology Department, School of Dental Medicine, University of Split (Croatia). Those individuals of unknown age or those with no third molars or showing badly rotated teeth, 80 (5.64%) were excluded from the evaluation sample. In total 1336 OPTs (758 females) were evaluated (Table 1).

Identification number of each patient, gender, dates of birth, and X-ray were recorded. In Croatia, each patient signs a general agreement with medical and dental institutions allowing dental record and radiographs to be used only for research and educational purposes, while preserving anonymity of the person. Agreement for usage of previously taken radiographs was approved by the Ethics Committee for Research Involving Human Subjects of the School of Dental Medicine, University of Zagreb, Croatia, and the study was conducted in accordance with the ethical standards laid down by the Declaration of Helsinki (DoH).

Table 1
Sample of panoramic radiographs from Croatia according to sex and age categories.

Age categories	Males	Females	Total
14	63	48	111
15	70	96	166
16	63	79	142
17	63	84	147
18	60	54	114
19	58	65	123
20	50	84	134
21	50	74	124
22	49	95	144
23	52	79	131
Total	578	758	1336

2.2. Measurements

All OPTs were done and stored in digital form using Orthopantomograph OP200D (Instrumentarium Dental, Tuusula, Finland) and images were recorded as computer files in JPG format. The digital images were examined by using the Corel Draw software package (Corel Draw v.12.0, 2003, Corel Corporation, Ottawa, Canada). Only the left permanent third lower molars, tooth No. 38 according to classification by Federation Dentaire Internationale (F.D.I.), were evaluated. Dental age estimation was performed according to the Cameriere et al. [29] method. The apical ends of the roots of the left lower third molar of each individual were analyzed and the third molar maturity index, I_{3M}, was defined as follows: if the root development of the third molar is complete, i.e., the apical ends of the roots are completely closed, then $I_{3M} = 0$, otherwise I_{3M} was calculated as the sum of the widths of the inner margins of the two open apices than divided by tooth length. Maturity index I_{3M} is evaluated in a similar way to the ratio A_i to L_i, when $i = 6$ or 7, as reported for the other two teeth with two roots in Cameriere et al. [32].

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 maturity index I_{3M} was done by the first author. Real age was calculated and recorded as difference between dates of OPT and dates of birth. A cut-off value of 0.08 was used for consideration if a person was a minor of 18 years of age or older, as described in DeLuca et al. [30]. Intra-class correlation coefficient (ICC) of I_{3M} was used for intra-observer agreement and inter-observer agreement among three different observers. Cohen Kappa was used for intra-observer agreement and Fleiss Kappa was used for inter-observer agreement among three different observers for agreement in selection on adult ($I_{3M} < 0.08$) or minor ($I_{3M} \geq 0.08$). Fifty randomly selected OPTs were re-examined one month after examination by the first and two other observers. The sensitivity of the test, p_1 (i.e., the proportion of subjects older than or 18 years of age who have $I_{3M} < 0.08$) was evaluated, together with specificity p_2 (i.e., the proportion of individuals younger than 18 who have $I_{3M} \geq 0.08$). The third molar index has been shown to be efficacious in discriminating individuals below and above the age of 18 years