

CAMERIERE'S THIRD MOLAR MATURITY INDEX IN ASSESSING LEGAL ADULTHOOD ON POPULATION OF BOSNIA AND HERZEGOVINA

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ABSTRACT

Introduction: Estimation of legal adulthood of an individual lacking identification documents represents one of the main challenges in modern science. This problem occurs in many European countries due to ethnic migration from countries affected by war and financial crisis. Age estimation based on dental parameters has been used for a long time in forensics. The third molar represents an important indicator for age estimation in the period from late puberty to the early twenties, due to its late development.

Aim: The aim of this study was to examine the impact of gender on the reliability and accuracy of the Cameriere's method in legal adulthood assessment based on third molar maturity index of individuals in Bosnian population.

Materials and methods: The study sample consisted of 300 digital orthopantomograms of persons aged between 13 and 24 years. The Cameriere's third molar method was used to estimate legal adulthood. (cut-off $I3M < 0.08$). The real chronological age was used as the reference standard. Results: The sensitivity of a test for cut-off value of 0.08 was 99.4% and specificity 91.0% (95% CI). The proportion of correctly classified individuals older than 18 years was 100% for men and 98.8% for women and for minors 95.2% for male and 88% for female.

Conclusion: This research has shown that the Cameriere's method can be applied in estimation of legal adulthood in the population of Bosnia and Herzegovina, but additional research with a larger sample is needed to form population-specific standards.

Key words: Cameriere's formula, third molar maturity index, legal adulthood

Introduction

As a result of global increase in cross-border migration, many countries have recorded an increasing number of asylum seekers in recent years without valid documentation providing proof of their date of birth. [1] Minors seeking asylum in developed countries are often involved in the process of illegal migration. In order to prevent abuse of the system and protect minors, many countries have introduced procedures for determining the age when it is questionable. [2] Assessing the age of individuals often requires an integrative approach including biological anthropology, medicine, forensic dentistry and radiology. Identification of people and determination of their age based on dentition has been recognized in the field of forensic medicine and forensic dentistry and several methods based on dental changes have been developed. [3] Determining the age of persons for forensic purposes is used as an aid in identifying persons without identity data, as well as in resolving medico-legal, civil or social problems, such as the actual age of minors in adoption processes, asylum seekers and prosecution of pedophilia and other issues. [3-7]

Dental development is a more reliable indicator of biological age in children compared to other parameters. [8, 9] Age assessment procedures based on radiological examinations of dental elements are non-invasive procedures, applicable to living people, simple to perform, give reliable results, reproducible and not very expensive. [10]

Researches have shown that the third molar is the most important indicator of maturity, especially in the period from late puberty to the early twenties, because it is the last element being completed in its development. [4, 7, 10-15] Development of third molars shows a special diversity among ethnic groups and therefore it is proposed to develop specific standards for forensic purposes based on research on different populations. [16, 17] Cameriere et al. published a method for determining adulthood based on the third molar maturity index and determined a specific cut-off value [3, 6, 18].

Aim: The aim of this study is to examine the influence of gender on the reliability and accuracy of the Cameriere's method for determining legal adulthood based on the third molar maturity index in persons within the Bosnian population.

Materials and methods

The sample of this study consisted of 300 digital orthopantomograms of subjects aged 13 to 24, made for other purposes (dental diagnostics and therapy). The analysis was performed retrospectively. The sample was collected in the private health institution "Dental Radiology" Mostar. Consent to use the recordings for research and scientific purposes was obtained directly from patients or, for minors, from their parents / guardians. The data used in the study are the gender, age of the patient and a teeth x-ray. The research was approved by the Ethics Committee of the Faculty of Dentistry with Clinics of the University of Sarajevo (number 02-3-4-203-8 / 2019). Inclusion criteria were: known sex and age of the individual (13-24 years), images of appropriate quality with minimal distortion, without pathology visible on the orthopantomogram. Exclusion criteria were: orthopantomograms without a specified date of birth, images without lower third molars present, image deformations, extracted or rotated third molars, fillings, crown restorations, caries, abnormalities or developmental anomalies that may result in inaccurate measurements. The real age in years was calculated as the difference between the date of recording of orthopantomograms (OPGs) and the date of birth of the subject serving as a reference standard. Dental age was estimated according to the Cameriere's method. Measurements were performed on the lower left molar, for standardization. For the analysis of the third molar maturity index, the widths of the projections of the open apices of the third lower molars (a and b) and the height of the molar (c) were recorded, using the computer program ImageJ. The third molar maturity index (I_{3M}) is defined as it follows: if the root development is complete, or if the root apices

are closed, then the index is calculated as 0. In the case when the root development is not completed, the index is calculated as the sum of the distances between the inner sides of two open apical tip (a, b) divided by the length of the tooth (c), i.e. according to the formula $I_{3M} = (a + b) / c$. Cameriere et al. proposed a cut-off value of $I_{3M} < 0.08$ for the determination of adults of both sexes. If $I_{3M} < 0.08$ the person is considered to be 18 or older, and if $I_{3M} \geq 0.08$ the person is considered to be under 18 years of age. Statistical data processing was performed in IBM SPSS statistical programs Statistics version 25 and MedCalc statistical software version 19.1.7.

Results

43.7% of individuals were male and 56.3% female. **Table 1** shows the number of orthopantomograms, in relation to gender and age.

Age (years)	Male	Female	Total
13	26	40	66
14	9	7	16
15	8	13	21
16	8	4	12
17	8	10	18
18	9	14	23
19	6	3	9
20	6	13	19
21	20	18	38
22	10	21	31
23	21	25	46
24	0	1	1
Total	131	169	300

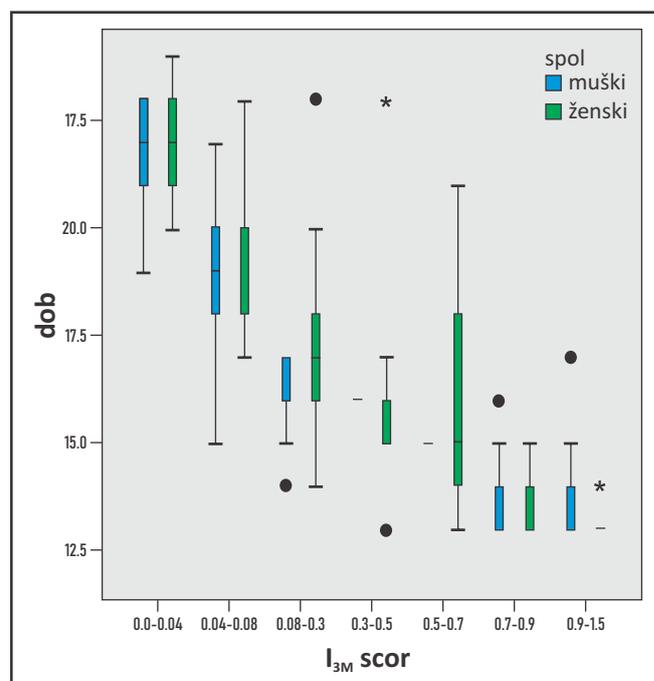
Table 1.
Distribution of subjects by age and gender in the total sample

To test the existence of significance of differences in chronological age between male and female subjects, the t test for independent samples was used. There is no significant difference in chro-

3M rank	gender	N	X	SD	P*
0.0-0.04	male	52	21.79	1.242	0.631
	female	64	21.89	1.041	
0.04-0.08	male	21	19.10	1.640	0.900
	female	25	19.16	1.818	
0.08-0.3	male	15	16.20	.941	0.150
	female	17	17.12	2.233	
0.3-0.5	male	2	16.00	.000	1.000
	female	9	16.00	2.828	
0.5-0.7	male	1	15.00	.000	0.734
	female	9	16.00	2.693	
0.7-0.9	male	20	13.65	.933	0.275
	female	26	13.38	.697	
0.9-1.5	male	20	13.50	1.000	0.065
	female	19	13.05	.229	

Table 2.
Chronological age in relation to I_{3M} index: number of subjects, arithmetic mean, standard deviation for males and females

nological age between male and female subjects classified according to I_{3M} ranks ($p > 0.05$). (**Table 2**) **Graph 1** shows the median and interquartile range of the chronological age of the subjects in relation to the I_{3M} ranks, while the beginnings and



Graph 1.
The relation between chronological age and I_{3M} index ranks for males and females

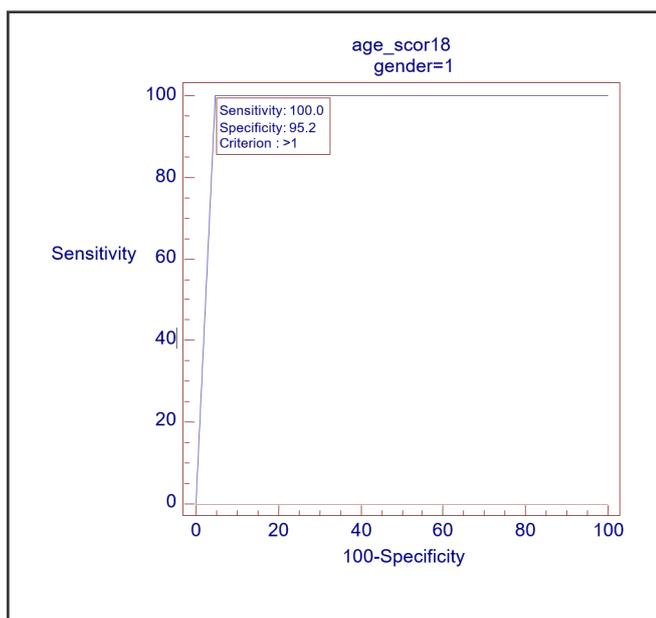
Gender		Age		Total
		<18 years	≥ 18 years	
male	$I_{3M} \geq 0.08$ (T=0)	59 ^c	38 ^d	62
		95.2%	4.8%	100%
	$I_{3M} < 0.08$ (T=1)	0 ^b	69 ^a	69
		0.0%	100.0%	100%
Total		59	72	131
		45.0%	55.0%	100%
female	$I_{3M} \geq 0.08$ (T=0)	73 ^c	10 ^d	83
		88.0%	12.0%	100%
	$I_{3M} < 0.08$ (T=1)	11 ^b	85 ^a	86
		0.2%	98.8%	100%
Total		74	95	169
		43.8%	56.2%	100%

^a – true positive ^b – false positive ^c – true negative ^d – false negative

Table 3.

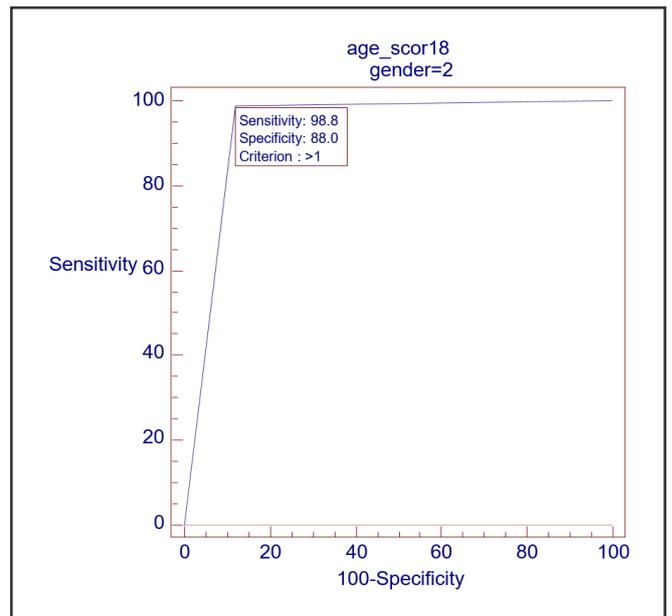
Contingency table shows correct classification of I_{3M} in relation to gender

endings of the lines refer to the minimum and maximum values. Deviation values are not included in the boxplot. They are shown by dots and stars. Distribution of real age gradually



Graph 2.

ROC curve of the I_{3M} index 0.08 for age of 18 for males



Graph 3.

ROC curve of the I_{3M} index 0.08 for age of 18 for females

decreases as the value of the index increases (**Graph 1**). The results of the I_{3M} applicability analysis are shown in the contingency table (**Table 3**), where among subjects aged ≥ 18 years, 69 (100%) males and 85 (98.8%) females were classified as true positive ($I_{3M} < 0.08$). Among minors (under 18 years of age), 59 (95.2%) males and 73 (88%) females were correctly classified ($I_{3M} \geq 0.08$).

Overall sensitivity of the test was 99.4% and specificity 91.0%. (95% CI). ROC curves show sensitivity and specificity of the cut off value of I_{3M} index 0.08 in estimation of adulthood for males is shown in **Graph 2**, and for females in **Graph 3**.

Discussion

The results of this study showed that the Cameriere's method of the third molar index is a good method for assessing legal adulthood in persons of both sexes in the population of Bosnia and Herzegovina, with an accuracy of 98.8% in females to 100% in males. However, our results show that the accuracy of determination of minors

is slightly weaker, ranging from 88% for females to 95.2% for males. The Study Group on Forensic Age Diagnostic for age estimations in living persons in order to increase diagnostic accuracy recommends the use of several different examinations in one person, such as physical examination, radiological examination of the left arm, dental examination including dental status and radiological imaging of dentition. Skeletal and dental age assessment plays very important role in the assessment of chronological age.[19]

Despite the fact that development of each person is influenced by genetic, nutritional, climatic, hormonal and external factors, tooth development is considered to be independent of external factors, such as malnutrition, various diseases, mental stress and environmental factors. Even in pathological conditions, tooth development is rarely affected. [5, 20, 21] A realistic age assessment is vital to ensure that children and juveniles are properly identified and treated. [22] Age assessment methods should minimize errors that are technically unacceptable (adults classified as minors) and, if possible, exclude ethically unacceptable errors (minors classified as adults). This applies in particular to the inclusion of criminal liability of presumed juveniles. [3, 18, 23] When assessing age, it is especially important that minors are not classified as adults, as this may lead to a violation of their legal rights, including the right to asylum, exploitation by adults or health services. [24] Two methods are available to assess the age of young adults: analysis of bone morphological characteristics and radiological examination of the third molar. [5, 25, 26] Cameriere and co-workers developed a practical method for determining adulthood based on the relationship between age and the third molar maturity index, which refers to measuring the open apices of the third molar. The limit value of the index $I_{3M} = 0.08$ was determined. [27] In the study on the population of Bosnia and Herzegovina, the sensitivity of the test was 99.4% and the specificity was 91.0%, which is higher compared to the study of Deitos on the population of Brazil (Se 77.4% and Sp 87.4%), and Cameriere (Se 70%, Sp 98%) and approxi-

mately the De Luca study on Italians (Se 86.6% and Sp 95.7%) [4, 5, 28]. Age assessment based on third molars cannot be performed in individuals who lack third molars or are intentionally extracted, and when it is not possible to measure the apical openings or the length of the tooth itself. Some authors in their research point to the possibility that some individuals might intentionally remove their third molars to prevent age assessment. [24]

It should also be noted that there are other useful indicators for estimating age with applicable confidence intervals, which need to be used in combination for the purpose of more accurate results. [24] The final assessment of age should be a synthesis of social and medical history, clinical findings, assessment of age and age calculated by statistical methods. [29] The use of the Cameriere's index in age assessment was first examined in the population of Bosnia and Herzegovina. Analysis of the results of research on the population of Bosnia and Herzegovina shows that the third molar maturity index can be an useful method for assessing adulthood. The development of third molars shows great diversity among different ethnic groups, so development of standards for forensic purposes has been proposed. Population-specific standards will increase the accuracy of forensic age estimates based on third molar mineralization in living individuals. [16, 17] A large number of authors in their studies state the need for larger and more extensive research in order to further examine the accuracy and reliability of certain methods and the involvement of forensic dentists in the legal process of determining the age limit of 18 years.

Conclusion

Research has shown that the Cameriere's method can be used to assess legal adulthood in the Bosnian population. Gender did not significantly affect the accuracy of adulthood assessment, but additional research with a larger sample is needed to form population-specific standards.

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