Legal Age Estimation Using Cameriere's Third Molar Method

SUMMARY

Background/Aim: Biological (dental) age represents the level of development of organic systems. The estimation of dental age plays a big role in dentistry, the law, forensics, and criminology. Cameriere's method is a simple and noninvasive way to determine the dental age, measuring the width of the open apex in left mandibular third molars. The modified Cameriere method is utilized for assessing the legal age of individuals and is based on the analysis of tooth 38 (left mandibular third molar). As the hardest tissue in the human body, teeth remain structurally unchanged long after a person's death. In addition to their durability, the morphology of teeth is unique to each individual, proving direct evidence of identity. Examination of accuracy, reliability and applicability of Cameriere's third molar index method for legal age assessment in cases in which the chronological age is unknown. **Material and methods:** *Two hundred and fourteen orthopanthomograms, acquired from the Dentistry Clinic of Vojvodina's radiographic database, were used in this study. The radiograms were analyzed using the Kodak program. The age range considered was between 15 and 25 years, regardless of gender and ethnic background. The calculations were done using Cameriere's formula and third molar index (I_{3M}). The optimal threshold value that separates minors from adults is $I_{3M} < 0.08$.* **Results:** *The accuracy for the male examinees had a value of 81.33% and for the females, a value of 79.98%.* **Conclusions:** *Cameriere's third molar index method in legal age assessment has been proven partially accurate in our population and has justified its use in forensic purposes.*

Keywords: Chronological Age, Dental Age, OPT, Third Molar Index, Legal Age

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Introduction

Chronological age is the period from birth to the present moment stated in years. Unlike chronological, biological (dental) age represents the level of development of organic systems. The ideal case would be the correlation between the two stated age division. However, often do they differentiate[1].

Methods for determining dental age can have various approaches, such as biochemical, morphological and radiological. Methods using the radiology approach are the most common due to their non-invasiveness, and simplicity, and the ability to be performed on both alive and deceased humans. Amongst the various radiological methods (Demirjian, Willems, Nolla) that utilize stages of tooth development, we selected Cameriere's for the purpose of this research[2-5].

The Cameriere method is based on determining dental age from orthopantomographic (OPG) tooth images and relies on measuring the ratio of open apex projections and crown height in seven left mandibular teeth. Teeth with fully formed roots hence closed apices are labeled as N_0. In single-rooted teeth with incomplete root development, the width between the inner sides of the open apex itself is measured and marked as A. In multi-rooted teeth, the value (A) is obtained by adding

the widths of both open apices (A_1+A_2), A1 representing the width of the mesial root, and A2 the distal one. To conclude the equation, the value A is divided by the length of the crown (L) on the tooth in question[2, 6, 7].

The modified Cameriere method is utilized for assessing the legal age of individuals and is based on the analysis of tooth 38 (left mandibular third molar). Cameriere introduces the concept of the third molar index (I_{3M}), which is calculated using a similar procedure to his previous one.

Formula. Measurements of the projections of open apices of the third molar ($Ai = a + b$) and the height of the third molar (Li) are used for the analysis

$$I_{3M} = [Ai / Li]$$

The age of 18 and above represents adulthood, while the age below 18 represents the minority status of the population, which is used as the dependent variable. Gender was proven to be an independent variable.

Based on previous research, the optimal threshold value that separates minors from adults is $I_{3M} < 0.08$. The effectiveness of this value has been confirmed in studies conducted in various populations, including our own[2, 8].

Taking into consideration that teeth are the hardest tissue in the human body, forensic odontology takes advantage of dental age, particularly the assessment of adulthood, as a significant factor in investigations and legal proceedings, hence, the aim of this research was to verify whether the third molar development index (I_{3M}) represents a reliable method for determining the legal age of individuals in cases where the chronological age is unknown[3, 5, 6, 9 – 14].

Material and Methods

The research was designed as a prospective study based on 214 digital radiographic (OPG) images. The subjects were selected from the radiographic databases of the Clinic of Dentistry of Vojvodina, department of Oral surgery. The age range considered was between 15 and 25 years, regardless of gender and ethnic background. The images used were taken for diagnostic or treatment purposes. Prior to conducting the research, the chronological age and gender of each subject, whose radiographs were used in the study, were recorded to determine the accuracy of the obtained results.

The radiographs included in this study were obtained using the orthopantomographic method and stored in the digital database of the Clinic of Dentistry of Vojvodina. Orthopantomograms show all the teeth of both maxilla and mandible, temporomandibular joints, sinuses and surrounding anatomical structures. Only high-quality images of patients with a presence of tooth 38 (lower left

third molar) were included in this study, excluding any artifacts and anomalies, specifically vertically positioned third molars. The radiographic analysis was conducted using the StomisSF9RoViewer software (Kodak) with the length measurement function, which was applied to the lower third molar.

On the OPG imaged that met the criteria, the determination of the third molar index (I_{3M}) was performed by measuring the projections of open apices (Ai), calculating their sum ($A_1 + A_2$) and dividing the sum by the tooth length (Li), as shown in Figure 1.
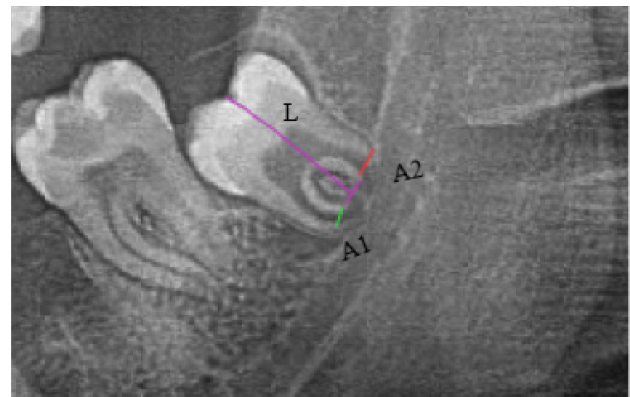

Figure 1. Variables shown on the third molar

The label A_1 on the image corresponds to the variable representing the width of the open apex of the mesial root of the third molar, A_2 corresponds to the width of the open apex of the distal root and the label L represents the length of the third molar.

For adults, the value of the third molar index is $I_{3M} < 0.08$, while for minors, it is $I_{3M} \geq 0.08$. If the third molar has completed the root development process, the value of the third molar index is considered to be $I_{3M} = 0.00$.

Results

The final sample of this research consisted of 214 participants and their orthopantomographic images. The participants' gender was considered an interdependent variable which did not affect the examination. However, the results will be classified by gender and described accordingly in the research findings, presented in tables one through six. Table 1 illustrates the distribution of participants by two variables, gender and chronological age. Table 2 presents the distribution of the third molar development index (I_{3M}). Table 3. displays the distribution of age according to I_{3M} classes and the gender of the participants. Table 4. displays the number of all participants and the number of correct determinations using Cameriere's method expressed in numerical and percentage values, classified by gender

and chronological age (values in the table are presented as whole numbers and percentages). Table 5. displays the true values of performed classification, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+),

negative likelihood ratio (LR-) and post-test probability. Table 6 displays the division of the number of male and female participants in three chronological age categories and the average of the third molar index within those participant groups.

Table 1. Distribution of participants by gender and chronological age

AGE	MALES	FEMALES	TOTAL
15	4	4	8
16	4	4	8
17	7	8	15
18	6	19	25
19	4	11	15
20	7	12	19
21	7	11	18
22	9	18	27
23	10	25	35
24	10	14	24
25	7	13	20
TOTAL	75	139	214

Table 2. Distribution of mean third molar development index (I3M < 0.08) for separating adult and minor male and female participants

TEST	AGE		TOTAL
	≥ 18	< 18	
MALES			
I3M < 0.08	48	2	50
I3M $\geq$ 0.08	12	13	25
MALES TOTAL	60	15	75
FEMALES			
I3M < 0.08	92	1	93
I3M $\geq$ 0.08	31	15	46
FEMALES TOTAL	123	16	139
TOTAL	183	31	214

Table 3. Summary of chronological age statistics by gender and classes of third molar development index (I_{3M})

I3M	N	MEAN	Sd	Min	Q1	Med	Q3	MAX
0.61 0.52	1	15	NaN	15	15	15	15	15
0.52 0.46	3	17.33	2.52	15	16	17	18.5	20
0.46 0.34	4	16.25	0.96	15	15.75	16.5	17	17
0.34 0.2	8	17.5	1.77	15	16.75	16.5	18.5	20
0.2 0.06	9	19.67	1.87	17	18	19	21	22
0.06 0.00	50	22.13	2.35	16	21	22.5	24	25
FEMALES								
0.61 0.52	2	17	2.83	15	16	18.5	18	19
0.52 0.46	0	0	0	0	0	0	0	0
0.46 0.34	12	18.67	1.83	15	18	18.5	19.25	22
0.34 0.2	18	18.11	2.19	15	17	17.5	19	23
0.2 0.06	14	19.79	3.02	16	17.25	18.5	22.75	25
0.06 0.00	93	22.07	2.16	16	21	23	23	25

N (number of participants), Mean (mean age within each I3M class), Sd (standard deviation of age), Min (minimum age), Q1 (first quartile of age), Med (median age), Q3 (third quartile of age) and Max (maximum age)

Table 4. Number of all participants and the number of correct determinations using Cameriere's method

AGE	MALES	CORRECT	%	FEMALES	CORRECT	%
15	4	4	100.00%	4	4	100.00%
16	4	2	50.00%	4	3	75.00%
17	7	0	0.00%	8	8	100.00%
18	6	3	50.00%	19	9	43.37%
19	4	2	50.00%	11	3	27.27%
20	7	4	100.00%	12	7	63.64%
21	7	5	71.43%	11	10	90.91%
22	9	6	66.67%	18	15	83.33%
23	10	10	100.00%	25	22	88.00%
24	10	10	100.00%	14	13	92.86%
25	7	7	100.00%	13	12	92.31%
TOTAL	75	53	70.67%	139	106	76.26%

Table 5. Results obtained from the frequency table

RESULTS	MALES	FEMALES
ACCURACY	81.33% (95%Cl, 80.98% to 81.66%)	76.98% (95%C1, 76.52% to 77.44%)
SENSITIVITY	80% (95%Cl, 79.67% to 80.32%)	74.79% (95%C1, 74.55% to 75.04%)
SPECIFICITY	86.67% (95%C1, 86.12% to 87.22%)	93.75% (95%C1 93.37% to 94.12%)
PPV	96% (95%Cl 95.83% to 96.17%)	98.92% (95%C1, 98.86% to 98.99%)
NPV	52% (95%C1, 51.37% to 52.63%)	32.6% (95%Cl, 32.17% to 33.04%)
LR+	6 (95%C1, 5.756 to 6.254)	11.97 (95%Cl, 11.26 to 12.71)
LR-	0.23 (95%C1, 0.227 to 0.235)	0.269 (95%Cl, 0.266 to 0.271)
VNT	96% (95%C1, 91.6% to 100%)	98.92% (95%Cl, 97.84% to 100%)

PPV (Positive predictive value), NPV (negative predictive value), LR+ (positive likelihood ratio), LR- (negative likelihood ratio), post-test probability

Table 6. The average third molar index values of participants in three chronological age categories

NUMBER OF MALES	PARTICIPANTS FEMALES	MALES	AVERAGE FEMALES
7	8	0.307	0.255
6	19	0.105	0.149
4	11	0.116	0.237

Discussion

After classifying the subjects into specific age groups, it was concluded that the largest sample consisted of patients aged 22 to 24 years chronologically. This can be attributed to the fact that these patients were referred to the department of Oral Surgery (where the study was conducted) for third molar extractions.

The results of our research produced reliable results in assessing legal age in both genders. The measurements were performed by a single individual with a relative measurement error coefficient of 95% and an obtained accuracy of 80%.

In the male population, the largest error in our study was observed in the age category of 17 years. Out of seven minor subjects, none of them were classified as minors using the Cameriere method (0%). Additionally, in the male participants in the (0.61-0.52) class, there was only one participant, resulting in no standard deviation.

The greatest errors in the female population were observed in the age categories of 18 and 19 years. In the 18-year-old category, out of 19 chronologically adult participants, only nine obtained accurate results (47.37%). In the 19-year-old category, the highest error rate as observed. Out of eleven adult participants, only three cases were accurately confirmed using the stated research method (27.27%).

Various studies have been conducted on the accuracy assessment of the Cameriere method, using the parameter of the third molar development index with the value of $I_{3M} < 0.08$ to distinguish between minor and adult participants. De Luca's research confirmed the significance of this method and emphasized the reduction of false negative results by using a third molar development index value of $I_{3M} < 0.08$, showing the accuracy of 91.4% [11]. In our study, using the same values of the third molar development index, we obtained lower accuracy rates (80%, 81.33% and 76.99%) compared to De Luca's study.

In a previous study conducted on the Serbian population in 2016., accuracy rates of 95% for the male population and 91% for the female population were obtained, which, along with our results confirms the hypothesis that the Cameriere method can be used to determine legal age in our population[8].

According to Dutch research, as well as the aforementioned study on our population, the male population had more accurate classification according to Cameriere, and the greatest errors were observed in the age groups of 18 and 19 years in both genders, which aligns with our research findings[8, 15].

Relatively inconsistent finding between other studies and our results can be contributed to differences in sample size, as well as etiological factors, as the development of teeth in each individual depends on their genes, diet, hormonal status and environment[3]. It is important to consider that not all humans have thirds molars and the timing of root development completion can vary among individuals. Additionally, some patients may refuse being exposed to X-ray imaging, which is the basis of this research.

Furthermore, measurements also depend on the software used in the study. The measurements in this study were performed using StomisSF9RoViewer software (Kodak) with a screen resolution of 1366x768, which may differ from other sources on the same topic (SIDEXIS, ImageJ, IBM SPSS 16.9 software program)[8, 15].

Our study validated the reliability and accuracy of the Cameriere method when applied to a comprehensive sample population. However, notable concerns emerge when the focus shifts to legal age assessment, specifically around the pivotal age of 18 years which signifies adulthood and legal responsibility. In this context, the

method exhibited a higher frequency of errors compared to previously documented studies. This discrepancy could potentially undermine its robustness for precise age determination within the legal framework necessitating the cautious approach when utilizing the Cameriere method for cases involving legal age assessment[8,11,15].

In light of the observed challenges with the Cameriere method in accurately assessing legal age, especially around the critical age of 18 years, we recommend the incorporation of supplementary non-invasive techniques to enhance the precision of age determination in this pivotal age group. By combining multiple modalities, a more comprehensive and reliable age estimation approach can be developed, ensuring a more accurate determination of legal age, which has far-reaching implications in matters of legal responsibility and societal rights.

Conclusions

In the study conducted on the sample of 214 participants, the accuracy rate was found to be 80%. The highest errors were observed among chronologically underage male subjects aged 17 and among chronologically adult female subjects aged 18 and 19. However, for other age groups in both genders, a high percentage of accuracy was obtained. This research indicates that Camerieres method of using third molar development index represents a relatively reliable approach for determining the legal adulthood of individuals in the population.

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