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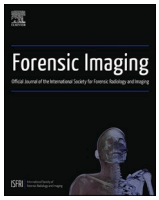

Age estimation by teeth and legal majority through the Olze method in Brazilian population

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ABSTRACT

Objectives: the aim of this study was to investigate whether the method proposed by Olze et al. (2012) is applicable for age estimation in Brazilian population and if it can estimate the legal age of majority. Materials and Methods: five hundred panoramic radiographs of Brazilian individuals between the ages of 15 and 24 of both sexes were used, and the stages for the formation of secondary dentin, periodontal recession, attrition and cementum apposition of the lower premolars were analyzed. The correlation between chronological and estimated age was verified through a multiple regression analysis. Results: the results showed that there was an overestimation of the chronological age for all teeth and age groups in both sexes, and the highest average difference between the chronological and the estimated age was 7.27 years for men and 5.41 years for women. Conclusion: the method proved to be useful for estimating the age of individuals 20 years old and older, and should be applied cautiously and as an auxiliary tool. However, it is not recommended to be used alone to estimate legal age of majority.

Introduction

In the context of forensic sciences, age estimation is not only seen as a requirement for an individual's death certificate, especially when information on the corpse is not available, but it also provides a basis for the investigation of crimes, mass disasters or war crimes [1]. In living people, age estimation has become essential due to growing migratory movements and an increase in cases where the age of individuals is unknown [2].

Age estimation plays a fundamental role when investigating whether an individual is of legal age, which in Brazil is 18 years old [3]. This process becomes extremely important in cases of offenders who claim to be unimputable, since the punishments for illegal acts committed by children (under the age of 12) are different when practiced by adolescents (12 to 18 years old) and by adults [4].

In the forensic field, teeth are considered to be tools that offer the most reliable results in age estimation process. In addition to having a rigid structure, being resistant to chemical and mechanical factors, any disorders that occur during the stages of dental development cause changes in this tissue that remain throughout life, which helps in estimating the age range of an individual [5,6].

In adolescents and adults, the oldest and best-known method is that of Gustafson [7], which analyzes six teeth alterations to estimate age: occlusal wear, gingival recession, secondary dentin deposition, cementum apposition, resorption, and root transparency. Olze et al. [8] proposed a modification to the Gustafson method and analyzed the formation of secondary dentin, cementum apposition, periodontal recession and wear of the lower premolars using panoramic radiographs.

Considering the great relevance that age estimation have for judicial decisions in different spheres, and also with the purpose of providing yet another method that helps the forensic area in the search for the real age of individuals, this research aimed to investigate whether the method proposed by Olze et al. [8] is applicable for age estimations of the 15-24 age group, and if it is reliable to estimate the legal age of majority in a

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Table 1
- Stages of the evaluated parameters and their respective definitions.

Secondary dentin formation	
Stage 0	Pulp horn reaches to above crown equator
Stage 1	Pulp horn reaches at maximum to crown equator
Stage 2	Pulp horn exceeds enamel–cementum boundary and falls short of crown equator
Stage 3	Pulp horn reaches at maximum to enamel–cementum boundary
Periodontal recession	
Stage 0	No periodontal recession
Stage 1	Periodontal recession into cervical root third
Stage 2	Periodontal recession into middle root third
Stage 3	Periodontal recession into apical root third
Attrition	
Stage 0	No attrition, cusp tips present
Stage 1	Beginning attrition with loss of cusp tips
Stage 2	Attrition reaching into dentin
Stage 3	Attrition reaching into dentin with opening of pulp cavity
Cementum apposition	
Stage 0	No visible cementum apposition
Stage 1	Beginning apical cementum apposition
Stage 2	Clearly visible cementum apposition, reaching beyond the apex

Source: Olze et al. [8]

Brazilian population.

Materials and Methods

The sample consisted of 500 panoramic radiographs of male (n = 250) and female (n = 250) Brazilian individuals aged between 15 and 24. The radiographic images were obtained from the collection of panoramic radiographs of the School of Dentistry of Ribeirão Preto (FORP) of the University of São Paulo, and the analyses started after ethical approval by the Research Ethics Committee (CAAE 18746619.0.0000.5440).

To be analyzed, panoramic radiographs should be of good quality, the age and sex of the individuals must be known and at least one premolar should be present. The exclusion criteria were the presence of restorative treatment, orthodontic treatment and other pathologies.

Olze et al. [8] suggested the evaluation of four parameters in the left and right lower premolar teeth to estimate age through the analysis of panoramic radiographs: formation of secondary dentin, periodontal recession, attrition and cementum apposition. Each parameter was analyzed according to the stages described in the original study (Table 1) [8] and are represented in Figs 1 to 2 3 4. Stage 3 of periodontal recession and stages 2 and 3 of attrition were not found in the analyzed radiographs and, therefore, are not reproduced in the corresponding figures.

For a better adjustment of brightness and contrast, radiographic

Fig. 1. - Demonstration of the stages of secondary dentin formation. Yellow arrows indicate the analyzed tooth.

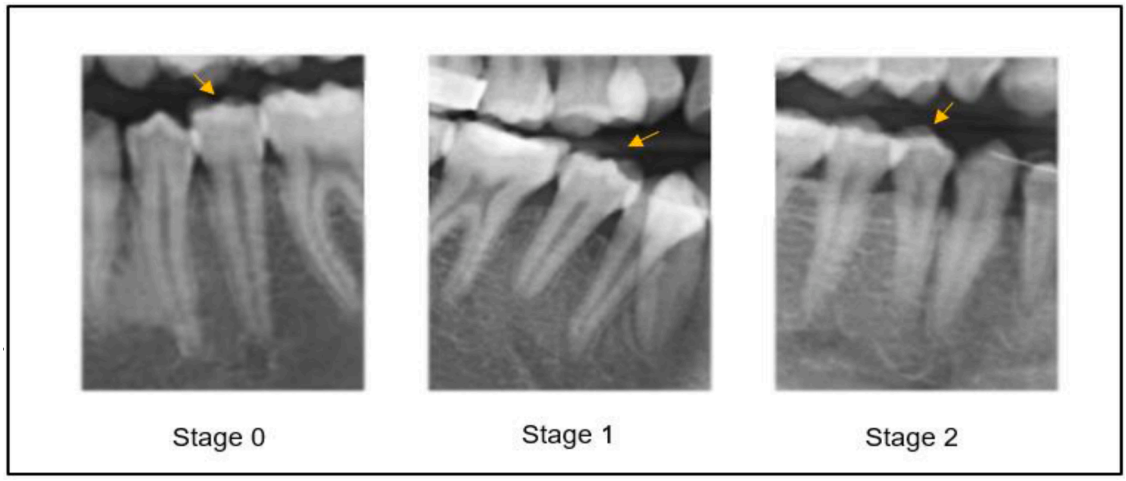

Fig. 2. - Demonstration of the stages of periodontal recession. Yellow arrows indicate the analyzed tooth.

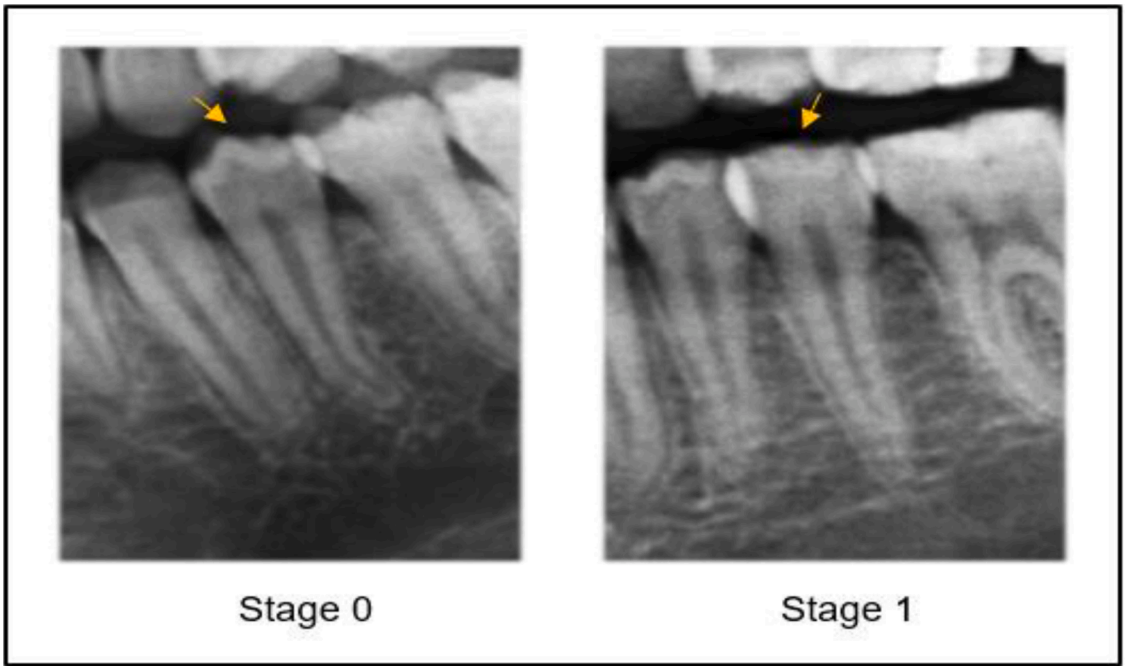

Fig. 3. - Demonstration of the stages of attrition. Yellow arrows indicate the analyzed tooth.

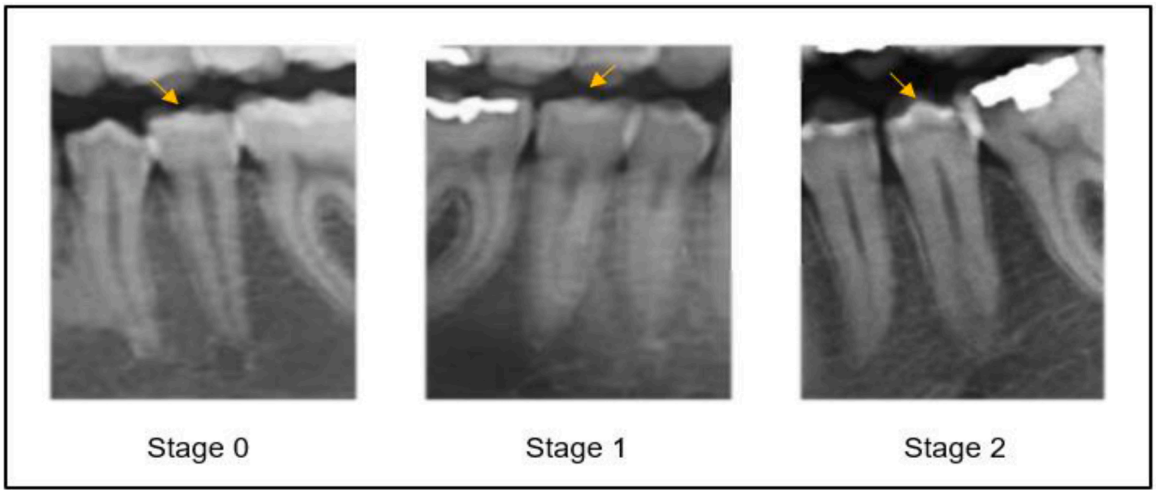

Fig. 4. - Demonstration of the stages of cementum apposition. Yellow arrows indicate the analyzed tooth.

images were analyzed using Microsoft Power Point® (Microsoft, USA). All panoramic radiographs were evaluated by a single examiner, who is an expert in Forensic Dentistry, after selection and randomization of the images, independently and without knowledge of the sex and age. The value corresponding to the stage of each parameter was added to the different formulas proposed by Olze et al. [8] for specific teeth and sex, in order to obtain the estimated age. Prior to the analyses, the examiner alignment was performed with the help of an individual with five years of experience in the field of Forensic Dentistry. Intra-examiner agreement was assessed based on reanalysis of 50 radiographs by the examiner.

The data were tabulated and organized in a Microsoft Excel® spreadsheet (Microsoft, USA) and statistical analyses were performed using SPSS software, version 22 (Statistical Package for the Social Sciences, IBM Corp. ™, Armonk, NY, USA). All variables were tested for normality using the Kolmogorov-Smirnov test. Assuming that all variables considered had a normal distribution, the *t* test was used to verify differences between chronological and estimated ages. For the analysis of possible differences in mean, analysis of variance (ANOVA) was used to adjust the estimated age, sex and teeth (34, 35, 44, 45). The Intraclass Correlation Coefficient (ICC) was applied to assess intra -examiner agreement. The level of statistical significance was set at $p \leq 0.05$.

Table 2
- Total missing teeth, excluded and evaluated.

Tooth	Number of missing teeth	Number of excluded teeth	Number of evaluated teeth
34	15	73	412
35	31	84	385
44	17	89	394
45	32	81	387
Total	**95**	**327**	**1578**

Table 3
- Mean difference between chronological and estimated ages according to sex for each premolar.

Tooth	Average	Standard deviation	Difference Average	CI (95%)	*t*	p value
Male						
Chronological	19.50	2.88	-	-	-	-
34	26.74	3.25	7.2772	6.70–7.86	-13.076	0.00001
35	26.46	2.41	6.4531	5.97–6.93	-15.114	0.00001
44	26.06	3.28	6.3089	5.74–6.88	-15.043	0.00001
45	25.78	2.17	6.4346	5.95–6.92	-15.007	0.00001
Female						
Chronological	19.50	2.88	-	-	-	-
34	23.25	2.29	3.5874	3.13–4.04	-16.417	0.00001
35	24.75	2.36	5.2667	4.77–5.77	-17.934	0.00001
44	24.63	2.89	4.7783	4.23–5.33	-15.449	0.00001
45	24.97	2.45	5.4192	4.88–5.96	-18.087	0.00001

CI - confidence interval; *t* - *t* test to assess means

Table 4
- Mean difference between chronological and estimated age in years, highlighted by age group and sex for each tooth.

Tooth 34[†]										
Chr age[*]	15	16	17	18	19	20	21	22	23	24
Female	9.45	7.82	7.38	5.37	4.70	3.43	2.70	1.45	0.23	1.46
Male	8.50	8.39	6.27	5.53	5.86	5.11	3.55	2.18	1.36	1.58
Tukey[‡]	H	GH	EF	DE	D	CD	BC	AB	A	AB
	Tooth 35[†]									
Chr age[*]	15	16	17	18	19	20	21	22	23	24
Female	10.58	8.18	9.32	6.00	6.09	3.57	3.96	1.74	1.66	1.08
Male	9.00	10.07	7.38	6.15	6.15	4.95	3.60	2.05	3.10	1.73
Tukey[‡]	F	F	F	DE	E	CD	BC	A	AB	A
	Tooth 44[†]									
Chr age[*]	15	16	17	18	19	20	21	22	23	24
Female	10.71	10.83	8.88	7.61	7.77	6.08	5.67	5.12	3.59	4.14
Male	11.64	11.15	10.50	7.00	7.19	5.72	5.44	5.87	3.40	2.94
Tukey[‡]	F	F	EF	CDE	DE	CD	BCD	ABC	A	AB
	Tooth 45[†]									
Chr age[*]	15	16	17	18	19	20	21	22	23	24
Female	10.17	11.08	8.46	7.26	8.42	5.94	5.93	5.15	4.16	2.11
Male	11.44	10.24	8.44	6.17	4.79	5.68	3.88	3.93	2.80	2.07
Tukey[‡]	F	F	E	DE	DE	CD	BCD	BC	AB	A

[*] Chronological age;
[†] significance of 95%, ($p < 0.05$);
[‡] F test - two-way ANOVA.

Results

The number of teeth that were analyzed, excluded according to the established criteria, and those that were absent, is shown in Table 2. The evaluation of the intra-examiner agreement resulted in values between 0.557 and 0.940. Thus, the reproducibility of the method in this population is considered moderate to almost perfect.

The average differences between the estimated and chronological ages were significant ($p < 0.001$), with overestimation in all age estimation formulas for both sexes. Greater mean differences were obtained when using tooth 34, which overestimated chronological age by approximately 7.27 years for males, and tooth 45, which overestimated by approximately 5.42 years for females (Table 3).

The ANOVA F test showed a significant difference in the age factor. However, sex was not significant, so there was no average difference between them. The "age x sex" interaction was also not significant, so sex and age act independently, that is, on average, ages behave equally for both sexes. From this, the *post-hoc* test was performed for the F test (Tukey's test), where equal letters indicate average equality between ages and the alphabetical order indicates how much more accurate the average of each age was. It can be seen that for teeth 34, 35 and 44, the ages of 22, 23 and 24 were more accurate, as they all had the letter A for the test applied, and tooth 45 estimated the ages of 23 and 24 years of age more reliably. In addition, it is possible to notice that teeth 34 and 45 were less accurate for the ages of 16 and 17. Likewise, teeth 35 and 44 were less acurate for ages 15, 16 and 17. Table 4 illustrates the data reported above.

Figs 5 to 6 7 8 show the relation between sex and age for each tooth and demonstrate that the larger the age group, the closer to the chronological age the estimate is, since the values of the average difference of the estimated age to the chronological one show that the closer to zero, the better the accuracy. Thus, it is noted that the age groups from 20 years old onwards were estimated more accurately while the younger ages (15 to 17 years old) presented greater average differences between the chronological and the estimated age.

Discussion

Age is one of the main points for establishing an individual's identity [9]. In living people, in addition to being useful for identification, age estimation is also related to existing legal conditions, since they prevent offenders from benefiting from falsely claiming to be younger. In contrast, they offer evidence that exempts individuals who are wrongly accused of providing false information about age [10].

In children and adolescents, the assessment of the degree of mineralization and eruption of teeth is the main criterion used to estimate age in living people [11]. However, when dental development is complete, age estimation is restricted to analyzing the progression of regressive changes in the hard and soft tissues of the teeth [12].

In this sense, the method by Olze et al. [8] proposes to analyze the

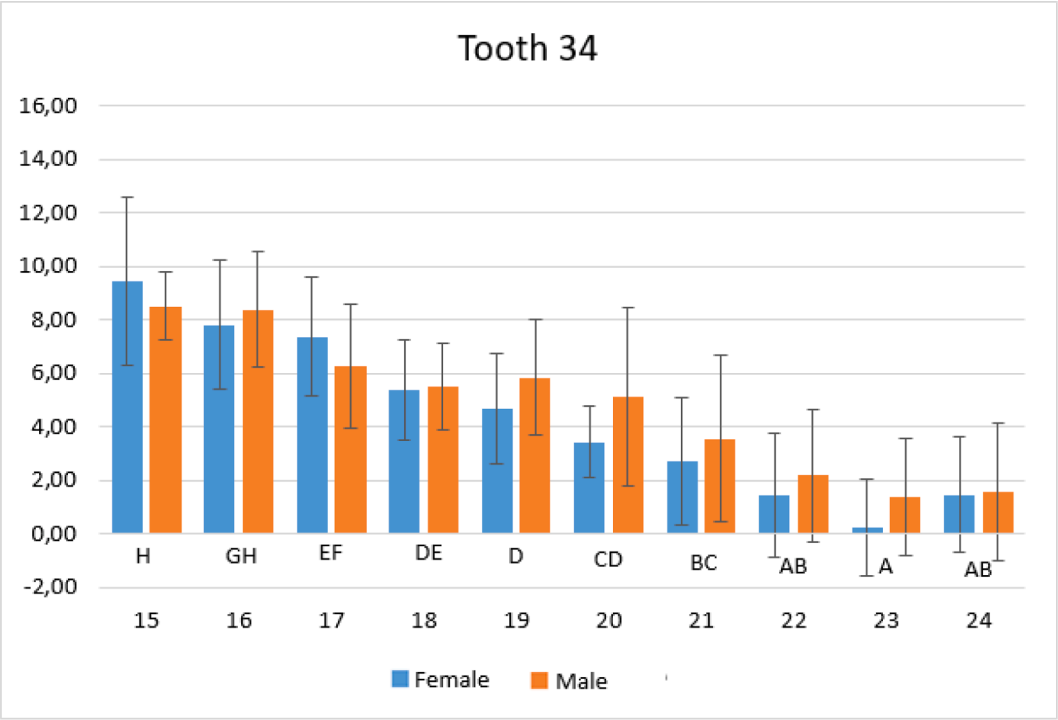

Fig. 5. - Relation between sex and age for tooth 34. The colorful bars show the difference between chronological and estimated age and the vertical black line indicates the confidence interval.

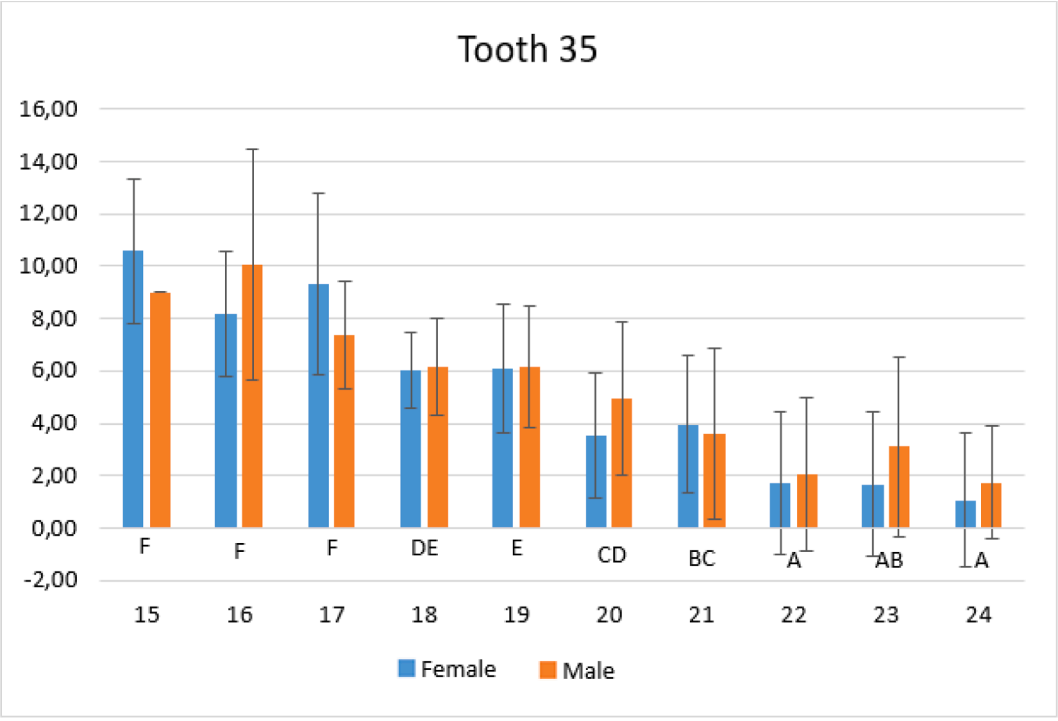

Fig. 6. - Relation between sex and age for tooth 35. The colorful bars show the difference between chronological and estimated age and the vertical black line indicates the confidence interval.

formation of secondary dentin, periodontal recession, attrition and cementum apposition in the lower premolars using panoramic radiographs to estimate age. The authors found that tooth 45 showed a better correlation with chronological age, obtaining the highest standard error of estimate of 5.5 years for males and 5.7 years for females. Thus, they recommended the method for application to living individuals, although it is limited by the quality of the radiographs.

An overestimation was observed for all ages in both sexes and, when the estimates were analyzed according to the tooth and sex, the smallest average difference obtained between the chronological and estimated ages was 3.58 years in females and 6.30 years in males, and the highest values were approximately 5.41 years for women and 7.27 years for

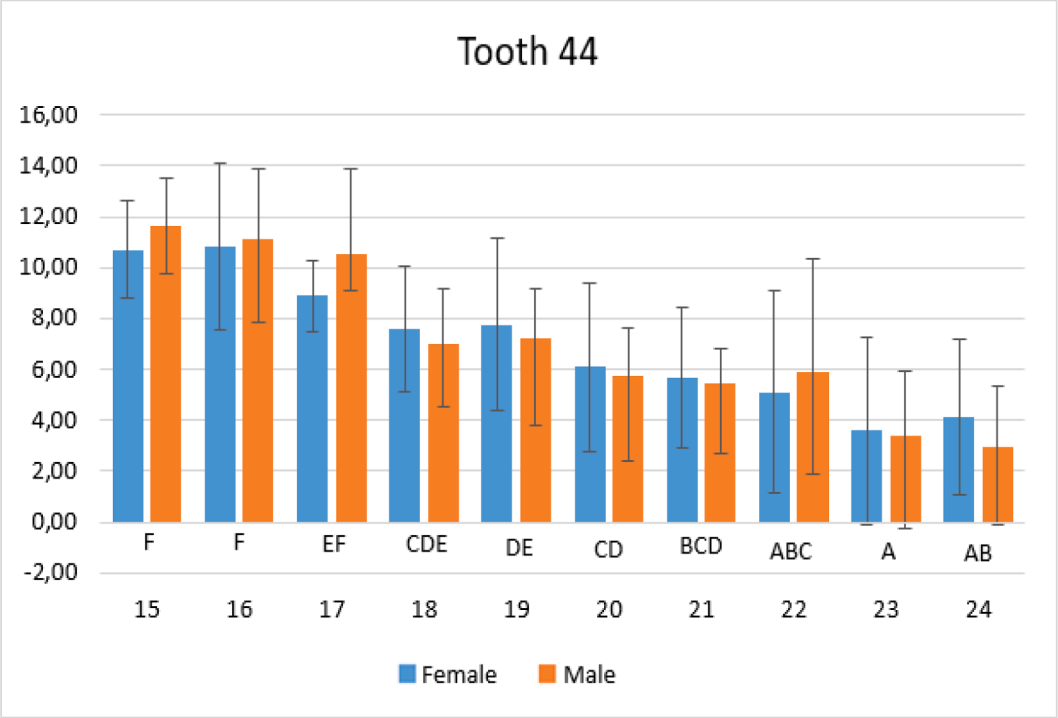

Fig. 7. - Relation between sex and age for tooth 44. The colorful bars show the difference between chronological and estimated age and the vertical black line indicates the confidence interval.

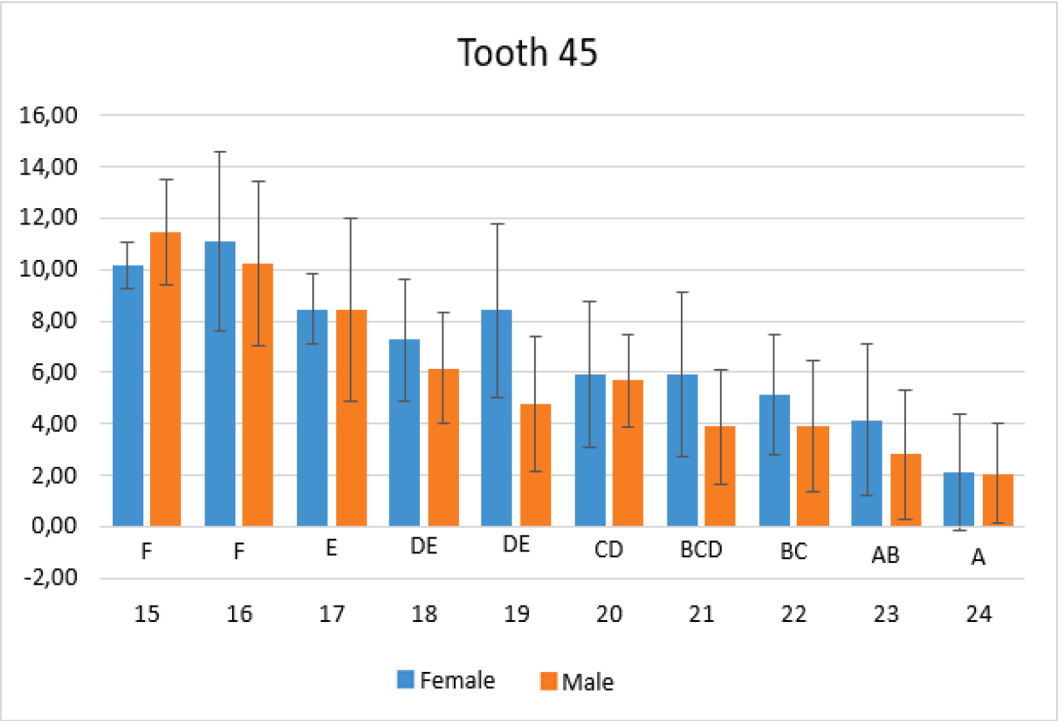

Fig. 8. - Relation between sex and age for tooth 45. The colorful bars show the difference between chronological and estimated age and the vertical black line indicates the confidence interval.

men. The average differences found do not differ excessively from the results of Olze et al. [8].

It is known that several factors can influence the final result of the estimate, such as nutritional status and the development of different degrees of activity, which can modify the nature and rate of physiological changes in age; social elements, sex, ethnicity and heredity [13,14]. In addition, the divergences in the number of individuals in each age group, in the total sample size, in the age range analyzed and the various statistical analyses applied can make it difficult to compare the results [6,8].

According to Solheim & Vonen [15], a standard deviation around 10 years is normal for most methods, being considered acceptable. Therefore, the mean difference values found for the method by Olze et al. [8] in this study indicates that the technique can be useful for the Brazilian population when it is necessary to estimate the age of an individual.

This study also verified the possibility or not of applying the method by Olze et al. [8] for determining the legal age of majority. In this sense, the results found were not positive. When evaluating the estimates according to the age group and sex, the ages of 15 to 17 years had less accurate results, presenting an average difference between the chronological and estimated age in an interval of 7.26 to 11.08 years for females and of 6.27 to 11.64 years for males. The age groups of 18 and 19 years got lower average differences, although they are still high when the intention is to check the penal age limit, maintaining values between 4.70 and 8.42 years.

These findings can be explained by the fact that the younger age group still does not show the regressive changes that the method assesses, since the age of children and adolescents is best estimated from the development and eruption of primary and permanent teeth. In addition, the most accurate results found for adults reinforce that, after 20 years of age, structural changes in teeth are fundamental for age estimation in individuals belonging to this age group [5].

Studies that estimated age using third molars found reliable results for this estimate [16–18]. In Brazil, Nobrega et al. [19] applied the third molar maturity index to estimate the age and revealed that the age threshold of 18 years was identified with good accuracy. However, Correia et al. [20] and Deitos et al. [21] stated that the technique was not satisfactory. Therefore, in forensic cases with this objective, it is recommended to use different available techniques and perform them repeatedly in order to obtain a reliable conclusion [22].

Studies that use the method proposed by Olze et al. [8] are few, but have shown their usefulness for age estimation, even if as an auxiliary tool. There are limitations related to the quality of the radiographs for the application of this methodology, but they can be circumvented by means of software that allows the formatting of images. It is important that other studies assessing this method are carried out, and that it be tested on periapical radiographs, since they present anatomical details in a detailed way. In addition, for the purpose of verifying the criminal age of an individual, we suggest that other studies be developed applying the method by Olze et al. [8] in conjunction with other age estimation methodologies.

Conclusion

The method proposed by Olze et al. proved to be useful for estimating the age of individuals over 20 years old, and should be applied cautiously and as an auxiliary tool. However, by evaluating regressive characteristics, it is not recommended to be used alone to estimate age in adolescents, individuals of legal interest age.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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