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Original Research Article

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Comparison of Cameriere's and Bedek's Methods for age Estimation in Mixed Dentition in the Population of Maharashtra

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Abstract:

Introduction: Age estimation is an integral part of Forensic Odontology. Numerous methods have been proposed to date, of which Cameriere's and Bedek's methods are two recently proposed radiographic methods of age estimation. The present study aims to evaluate the validity and reliability of Cameriere's method and Bedek's method of age estimation in the population of Maharashtra.

Materials and methods: The present retrospective study utilized 100 orthopantomograms (OPGs) of children aged between 6 and 15 years. The radiographs were analyzed by Cameriere's open apex method and Bedek's method for age estimation using Image J Software.

Results: There was an overestimation of age with a mean difference of 1.14 years in males and 1.04 years in females. There was a mean underestimation of age ranging from 0.745 to 1.060 years including all the models when using Bedek's method. There was a statistically non-significant difference ($p>0.05$) between the mean estimated and chronological age in all the models of Bedek's method except for the 2-teeth model in males.

Conclusion: Both, Cameriere's as well as Bedek's methods are relatively non-invasive and simple to apply for age estimation in Forensic Odontology. The relatively newer Bedek's models for age estimation showed better results in terms of accuracy and reliability.

Keywords: Forensic Odontology; Dental Age; Panaromic Radiography; Open Apices; Orthopantomogram.

Introduction:

The dental hard tissues demonstrate extreme resistance to physical, thermal, and corrosive environments. They develop systematically in a well-known chronological sequence, which does not vastly vary on environmental, genetic, or nutritional factors.[1] Therefore, teeth are very reliable sources of evidence in the forensic field that can withstand the test of time for hundreds of years. Age estimation has always been an integral part of forensic odontology and thus, a number of methods have been developed to utilize teeth for the purpose.[2]

Radiographic methods have recently gained popularity owing to their non-invasive nature, relative simplicity, and high reliability. A method of age estimation based on the proportion of the width of open apices and length of the teeth was proposed by Cameriere et al. in 2006.[3] Since then, numerous studies have been conducted to validate the method in conjunction with different formulae across different populations.[4] Even so, the court of law demands as high a probability of a method as possible, to deem it as justifiable evidence. Thus, there exists a need to constantly validate the method across different geographical locations

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in order to make the findings more reliable and valid in legal or criminal cases.

One limitation of Cameriere's method is that it requires all the teeth to be present on at least one side of the mandible (excluding third molars). Thus, its applicability becomes limited when there are one or more missing teeth on both sides. To overcome this drawback, Bedek et al. developed several models of age estimation based on thepresence of one to seven mandibular teeth.[5]The method has been tested in populations of Croatia, Brazil, and South India; however, to date, none of the studies have tested its applicability to the population of Maharashtra.[5,6]

The present study aims to evaluate the validity and reliability of Cameriere's method and Bedek's method of age estimation in the population of Maharashtra. Our study also has the objectives to determine the advantages and limitations of each of the methods and compare them in terms of practical applicability, accuracy, and reproducibility.

Materials and methods:

The present retrospective study utilized 100 orthopantomograms (OPGs) of children aged between 6 and 15 years. All the OPGs were obtained from the institutional archives; none were specifically taken for the purpose of the study. Ethical approval was obtained by the institutional ethical review board. OPGs from patients who were residents of Maharashtra, aged between 6 to 15 years, having all the permanent teeth present in the mandibular left quadrant (except third molars) were included. Exclusion criteria were OPGs with ambiguous demographic details, gross pathology of permanent teeth, history of systemic diseases, and congenital anomalies. OPGs with obscured apices due to erroneous angulation or crowding of teeth were excluded. Low-quality radiographs with pixelation, not suitable for analysis, were also excluded from the study.

The co-investigator not participating in the analysis of the radiographs noted down the demographic details of the patient and assigned a code to the digital file of the OPG.All the data relevant to the patients were removed from the file.Chronological age (CA) was decided as the date of exposure of the patient minus their date of birth. Further analysis was performed by Image J Software.

Analysis by Cameriere's method:

Seven left permanent mandibular teeth were considered, excluding the third molar. The number of teeth with closed apical ends (N) was determined. For teeth with open apices, the distance between the inner sides of the open apex was measured (Ai, ibeing the toothelement number). For those teeth with two roots (i = 6 and 7), the sum of the distances between the innersides of both apices was calculated. To avoid distortions by possible differences in magnification or angulation, the measure Ai was divided by the tooth length (Li), so that xi = Ai⁄Li.

The measures obtained were used to estimate age, according to the original formula provided by Cameriere et al.[3]:
Dental Age = 8.971 + 0.375g + 1.631*x5 + 0.674*N – 1.034*S - 0.176S*N0 where g is a variable- 1 for boys, and 0 for girls; x5 = A5⁄L5; N = number of teeth with closed apical end; and S = sum of normalized open apices (S = x1 + x2 + x3 + x4 + x5 + x6 + x7).

Analysis by Bedek's method:

The developmental stages of seven permanent mandibular teeth on the left side of the jaw were evaluated using Demirjian's method.[7] For the 7-teeth model, all the teeth of the mandibular left quadrant were analyzed. For the subsequent models, the teeth excluded from the analysis are listed in Table 1. Coefficients were assigned gender-wise based on the developmental stages of the teeth as per Bedek's original models.[5] The coefficients of individual teeth were summed up. The age of each individual was calculated by the formula:

Dental age= Intercept value + sum of coefficients assigned to the tooth stages.

The intercepts for each tooth model are also listed in Table 1. The radiographs were analyzed by two independent observers (HK and SS) to minimize bias in image analysis and interpretation. The co-efficient values obtained using intra-class co-efficient analysis were 0.84 for Cameriere's method and 0.94 for Bedek's method, which implied that there was a good agreement between the two observers for both methods.

Statistical analysis:

Data obtained was compiled on an MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States) and subjected to statistical analysis using the Statistical package for social sciences (SPSS v 26.0, IBM). Descriptive statistics, mean,and standard deviation for numerical data were determined. Inter-group comparison between the genders was done using t-test. For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving power to the study as 80%.

Results:

Out of the 100 patients, 50 were males and 50 were females. The mean estimated and chronological age for OPGs analyzed by Cameriere's method is depicted in Table 2.

It can be interpreted from Table 2 that there was a statistically highly significant difference seen for the values between the groups ($p<0.01$) for overall populations (mean discrepancy = 1.091 years) and males with higher values in EA by Cameriere's method as compared to the CA (mean discrepancy = 1.144 years). A significant overestimation ($p<0.05$) was also noted for the females with a mean discrepancy of 1.039 years.

As for the estimation of age by Bedek's method, the overall discrepancy by various models is concised in Table 3. There was a statistically non-significant difference ($p>0.05$) seen for the values of EA in males and CA in all models except for the 2-teeth model. The difference was non-significant for all the models in females. This indicates that the age estimated by Bedek's method is reliable and accurate except for the 2-teeth model which comprises analysis by very few teeth.

Discussion:

The major advantage of the radiographic methods for age estimation is that they are relatively non-invasive and do not require extraction of teeth, as compared to other histomorphological analytical methods. Cameriere's method employs a ratio of vertical to horizontal dimensions, thereby minimizing any discrepancy caused by radiographic image distortion. Although distortion may vary along the horizontal and vertical axes, it has seldom been found significant enough to affect the ratio.[8]

A practical limitation of Cameriere's method is that the method requires all the teeth (except the third molars) to be present on at least one side of the mandible. Therefore, the method cannot be applied in cases of hypodontia, the presence of pathologies in permanent teeth, or when multiple teeth are missing in incomplete human remains. In such scenarios, the shortcoming is overcome by the models developed by Bedek et al. which account for the multiple missing teeth.

Similar studies using Cameriere's open apex method in populations from other regions of India have found varied and contrasting results. The results of our study indicated that there was an overestimation of age with a mean difference of 1.14 years in males and 1.04 years in females. A similar but lower overestimation of age by 0.70 years in males and 0.60 years in females was found in the North Indian population by Rai et al.[9] Vadla et al. found a relatively lower overestimation of 0.02 years in males and 0.22 years in females, in a South Indian population-based study.[10] On the contrary, a study by Ganepalli et al. on the south Indian population sample found a mean underestimation of 1.50 years in males and 1.54 years in females.[11] The differences amongst various populations may be attributable to ethnic and environmental factors.

In our study, including all the models in Bedek's method, there was a mean underestimation of age ranging from 0.745 to 1.060 years. A recent study in the Turkish population (n=1118) found a relatively lower underestimation ranging from 0.1 to 0.2 years by Bedek's method.[12] To the best of our knowledge, no similar studies on the Indian population have been published and consequently, there was no relevant regional data to compare with. On the other hand, there was a mean overestimation of age by 1.09 years by Cameriere's open apex method. Therefore, even the models of Bedek's method with fewer teeth gave lower discrepancy as compared to Cameriere's open apex method.

The higher discrepancy in analysis by Cameriere's open apex method may be a result of a combination of various reasons such as difficulty in the analysis of the near-closed apices of roots in patients of older age group,[13] or significant exceedance of radiographic distortion in the either vertical or horizontal direction than its counterpart.[8] Such errors attributable to the method or physiology are relatively more difficult to deal with and are not involved in analysis by Bedek's method.

The relatively lower number of samples could be a possible limitation of our study. It was both an ethical as well as professional decision to restrict the OPGs used for the study to be retrieved retrospectively only from the departmental archives. Exposing the patients to radiation without any clinical relevance solely for the purpose of the study is not ethically justified. Two individuals, despite being of the same age, may exhibit differences in the chronological development of teeth owing to several nutritional, environmental, and ethnic differences.[14] This may constitute an additional drawback of using radiographic methods for the estimation of age, particularly in legal or criminal cases.

However, this difference between individuals highlights another utility of the radiographic age estimation methods in

Pediatric Dentistry and Orthodontics where the treatment planning is based on the stages of development of teeth rather than the chronological age.[15] Further studies covering these aspects of the utility of the radiographic methods of age estimation can also be conducted. Obviously, there still exists a need to further validate the applicability, accuracy, and reliability of the methods by conducting multiple studies with adequate sample sizes in different geographical locations.

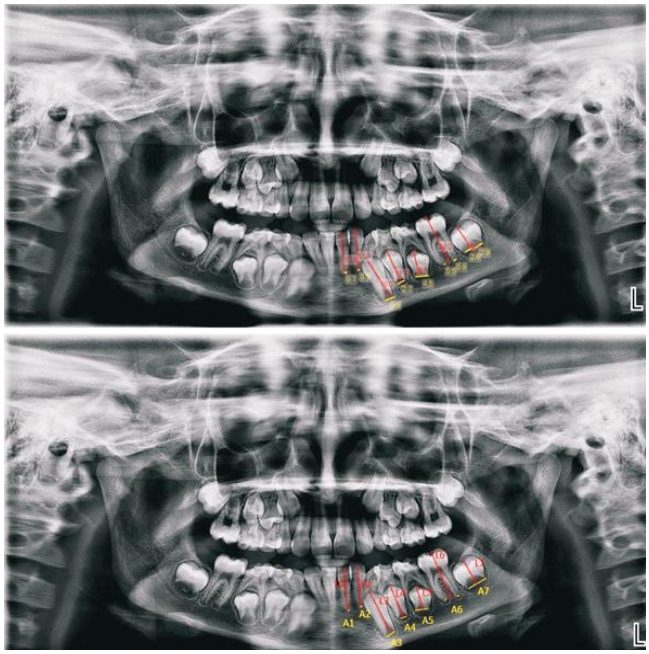

Figure 1: An example of analysis by Cameriere's method. The upper radiograph shows values obtained by Image J Software; the lower radiograph shows corresponding labels in the formula. ('A' represents the width of the open apex; 'L' represents the vertical length of the tooth)

Table 1: Teeth used in different models for analysis by Bedek's method and their corresponding intercept values for

	Teeth excluded from the analysis		Intercept value	
Model	**Males**	**Females**	**Males**	**Females**
7-Teeth	None	None	4.396	5.095
6-Teeth	LI	CI	4.544	5.077
5-Teeth	LI + 2nd PM	CI + 2nd PM	4.664	5.079
4-Teeth	LI + 2nd PM + 1M	CI + 2nd PM + 1M	5.451	5.122
3-Teeth	CI+ LI + 2nd PM + 1st M	CI+ C + 2nd PM + 1st M	6.069	5.350
2-Teeth	All except 1st PM + 2nd M	All except 1st PM + 2nd M	5.370	5.350
1-Tooth	All except 1st PM	All except 2nd M	5.828	5.771

(Table Legend: CI = Central Incisor, LI = Lateral Incisor, C = Canine, PM = Premolar, M = Molar)

Table 2: Overall and gender-specific mean chronological and estimated age by Cameriere's method

CAMERIERE'S METHOD		N	Mean Age (years)	Std. Deviation	Std. Error Mean	T value	p value of t test
Overall	EA	100	9.231362	1.7302480	.2446940	3.453	.001**
	CA	100	8.140000	1.4143579	.2000204		
Males	EA	50	10.104008	1.4074299	.2814860	3.436	.001**
	CA	50	8.960000	.8888194	.1777639		
Females	EA	50	8.35872	1.595279	.319056	2.465	.017*
	CA	50	7.32000	1.375984	.275197		

(Table Legend: EA = Estimated age; CA = Chronological age)

Table 3: Mean estimated age and discrepancy in various models for analysis by Bedek's method

	Chronological age	Estimated age						
Models		**7 Teeth**	**6 Teeth**	**5 Teeth**	**4 Teeth**	**3 Teeth**	**2 Teeth**	**1 Tooth**
Mean	9.26	8.51464	8.44906	8.19988	8.32556	8.24314	8.16078	8.9562
STD Dev	2.183519	2.055604	1.941515	1.929218	1.941515	2.037189	2.090974	2.215518
Upper value of range	14	15.316	14.182	14.315	15.414	15.351	15.299	16.923
Lower value of range	6	4.631	4.42	4.42	5.417	5.35	5.35	5.771
Discrepancy		-0.74536	-0.81094	-1.06012	-0.93444	-1.01686	-1.09922	-1.3038

Conclusion:

Both, Cameriere's as well as Bedek's methods are relatively non-invasive and simple to apply for age estimation in Forensic Odontology. The relatively newer Bedek's models for age estimation show promising results in terms of accuracy and reliability. The models offer a unique advantage owing to their ability to estimate age even in the absence of multiple teeth, making them the preferred choice in cases of incomplete human remains or multiple missing teeth. The applicability, accuracy, and reliability of these methods require further validation by studies with large sample sizes in populations of different geographic regions.

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