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Journal of Oral Medicine, Oral Surgery, Oral Pathology and Oral Radiology

Journal homepage: www.joooo.org

Original Research Article

Comparative assessment of Demerijian's and Cameriere's dental age estimation in children - A panaromic radiographic study

Aparna Srivastava[1], Poornima Govindraju[1,*], Balaji Pachipulusu[1], Mahesh Kumar T S[1]

[1] Dept. of Oral Medicine and Radiology, Rajarajeswari Dental College and Hospital, Bengaluru, Karnataka, India

ARTICLE INFO

Article history:
Received 11-04-2022
Accepted 13-05-2022
Available online 18-06-2022

Keywords:
Demirijian's method
Cameriere's Method
Forensic science
Age estimation
Open apex
Panoramic radiographs

ABSTRACT

Background and Objectives: Age estimation in children is a fundamental question in forensic medicine and in treatment planning. Estimation of age is required to answer a variety of legal questions like status of majority and criminal liability such as in child marriage, sexual harassment and in situations where birth data is lacking or doubted.

Various methods have been proposed for assessment of the dental maturation, but the most widely applied method is by Demirijian et al. Cameriere's method is also used to assess chronological age in children with open apex. With this background, the present study was conducted to estimate the dental age of the children from open and closed apex.

Methodology: 240 digital panoramic radiograph of patients aged between 5 and 15 years were taken randomly Dental age estimation was performed using by Demirijians and Cameriere's method.

Results: The mean difference between the chronological and dental age was found to be 3.93 and 0.17 for Demirijian's and Cameriere's age estimation method respectively. In Demirijian's method, the accuracy was found more in older females where as in Cameriere's method the accuracy was almost same in all the age groups and the precision was seen in males than in females, on comparison Cameriere's age estimation method was more accurate than Demirijian's method.

Conclusion: Dental maturity can be used to assess chronological age in children either by Demirijian's or Cameriere's method, Cameriere's method was more accurate than Demirijian's method.

1. Introduction

Identification of an individual, living or dead is based on the fact that all individuals are unique. Hence, personal identification has become increasingly important in legal medicine. Physiologic age is based on the growth and maturation of one or more tissue systems and is measured by the occurrence of one or a sequence of irreversible events.[1]

The age assessment of living individuals is an area of increasing interest in our community, due to the progressively higher number of persons are not in possession of any document of identity or whose birth certificate may be suspected to be wrong, who have immigrated illegally or committed crimes, whose real age must be known in order to decide whether they can be charged.[2]

Age estimation in children is a fundamental question in forensic medicine and in treatment planning as it is needed to estimate the age of living individuals to answer a variety of legal questions including status of majority and criminal liability such as in child marriage, commercial and sexual harassment, in situations where birth data is lacking or doubted.[3]

* Corresponding author.
E-mail address: drpoornimag@gmail.com (P. Govindraju).

https://doi.org/10.18231/j.jooo.2022.013

Several methods have been advocated for age estimation in children. Among all, Skeletal maturity has been considered as the most reliable method but this method has certain drawbacks in view of the considerable variability in bone maturation which is influenced by various environmental factors, so the dental structures are more suitable tools for age estimation in children as the calcification rate is more controlled by their genes than environmental factors.[4]

Various clinical and radiographic methods have been proposed for dental age estimation. These are based mainly on the stages of tooth development, sequence of eruption and regressive alterations in teeth. Estimating chronological age by means of the dental mineralization stage is not a straightforward analysis, and it is fundamental to ascertain the validity of these methods and their applicability to younger populations.[2]

With the above background the aim of the study was to estimate age among children using Cameriere's open apex method and Demirijian's method on panoramic radiograph and also to assess the most accurate method between them.

2. Materials and Methods

240 panoramic radiographs of patients aged between 5 to 15 years were taken using(SIRONA Orthophos XG5) Digital OPG Machine after getting approval from the institutional ethical Committee with the following inclusion and exclusion criteria.

2.1. Inclusion criteria

1. Age should be between 5 and 15 years.
2. No agenesis or extraction of teeth in the left mandibular quadrant.
3. Good quality panoramic radiographs.

2.2. Exclusion criteria

1. Premature birth.
2. Evidence of any systemic illness and congenital anomalies.
3. Radiograph showing gross pathology and previous orthodontic treatment.

The patient's identification number, sex, date of birth and date of radiograph were recorded after taking consent from patient's parents. All subjects were divided into 10 groups according to their chronological age with equal sex distribution. The chronological age was calculated by subtracting the date of radiograph taken from the date of birth. Age was estimated by Demirijian's method and Cameriere's method.

The Demirjian method was based on eight stages (from A to H) of dental maturity in the seven left permanent mandibular teeth, observable on panoramic radiograph. Each tooth was attributed a stage and converted in quantitative values by applying a specific table, the scores of the seven teeth are summed as a function of sex and the sum of dental maturity was obtained on a scale of 0 to100. The total was converted in dental age using a table for converting the results of dental maturity.[5] The total maturity score (S) was then substituted in the following formula to derive the age.

1. For males, Age = 27 4351 – (0 0097 X S^2 + (0 000089 X S^3)
2. For females, Age = 23 7288 – (0 0088 X S2 + (0 000085 X S3)[6]

Dental age estimation was performed according to the method of Cameriere et al(2006), the number of teeth with complete root development, i.e., apical ends of the roots completely closed (N0), was counted. Teeth with incomplete root development, i.e., with open apices, were also examined and the distance (Ai,i = 1,. . . ..,7) between the inner side of the open apex was measured using SIDEXIS software. In order to consider the effect of possible differences among X-rays in magnification and angulations, measurements were normalized by dividing by the tooth length (Li, i=1,. . . ., 7). Dental maturity were evaluated according to the normalized measurements of the seven left permanent developing mandibular teeth (xi = Ai/Li, i = 1,.. 7), the sum of the normalized open apices (s) and the number (N0) of teeth with complete root development.[3]

The data was analyzed using SPSS (Statistical package for social sciences) software V.22, IBM, corp. Stepwise linear regression analysis was done to obtain the gender specific prediction equations for estimating the dental age through Cameriere's method. Karl Pearson correlation test was used to estimate the correlation between the chronological and dental age for both Demirijian's estimated age and Cameriere's estimation age. Student t test was used to compare the study parameters between the chronological and the dental age estimation methods within males and females.

3. Results

The present study consisted of 240 subjects which included 120 girls and 120 boys which was divided into 10 groups according to age. Each group was divided into 12 males and 12 females. All the measurements were carried out by 2 observers, to test the inter and intra observer variability a random sample of 50 panoramic radiographs were re-examined after an interval of 1 month which was found to be statistically nonsignificant (p value 0.49).

In Demirijian's method the maximum accuracy was seen in the age group of 11-12 years and the maximum mean error noted was 0.27 and 0.18 in 11-12 years respectively in females and males, which reveals that the accuracy of dental estimated age is more in older females and males. (Tables 1 and 2).

Gender wise comparison of the mean age by Demirijian's estimated method was 0.72 years and error with respect to chronological age was 0.62 years which reveals that the accuracy of Demirijian's estimated age is more in females than in males. (Table 3)

The overall comparison of the mean age between chronological and estimated Demirijian's age was 9.91 and mean of Demirijian's estimated age was 13.84 and mean difference was 3.93 which was statistically significant with p-value <0.001 (Table 4).

In Cameriere's method, the relationship between chronological age and the Cameriere's parameter using pearsons correlation statistics is shown in Table 5 which unveils that variable which were used in Cameriere's method Ai, Li and Xi were found to be statistically significant (p-value<0.001).

The stepwise linear regression model analysis is shown in Table 6. On the basis of adjusted R2 values most influential variables for the age estimation were taken by linear regression model, The value of adjusted R2 for Xi and Ai was 0.72 and for Li and Ai was 0.83.

Male predictors used for the regression equation are Xi and Ai and for females, the predictors were Li and Ai (Table 7) and the regression equation was derived as shown in Table 8.

The accuracy of Cameriere's estimated age was approximately same in all the age groups. The maximum accuracy was seen in the age group of 11-12 years followed by 10-11 years in females and whereas in males, maximum accuracy was seen in the age group of 8-9 years followed by 7-8 years. The maximum mean error noted for females was 2.07 for the age group of 5-6 years and the minimum mean error was 0.28 noted in 11-12 years in females (Table 9). The maximum mean error noted for males was 1.6 for the age group of 5-6 years and the minimum mean error was 0.07 noted in 8-9 years (Table 10). The accuracy of the Cameriere's estimated age was more in males than in females (Table 11).

The overall comparison of the mean age between chronological and estimated Cameriere's age was almost similar with mean difference is -0.17 and the mean of error between Cameriere's estimated age and chronological age was found significantly lower than the error between Demirijian's estimated age and chronological age (Figures 1 and 2).

4. Discussion

In the present study, the maximum accuracy was seen in age group of 11-12 years in males and 9-10 years in females using Demirijian's method which was in accordance with previous studies conducted by Nykamen et al,[6] Mohammad et al.[7] In the present study, Demirijian's estimated age is

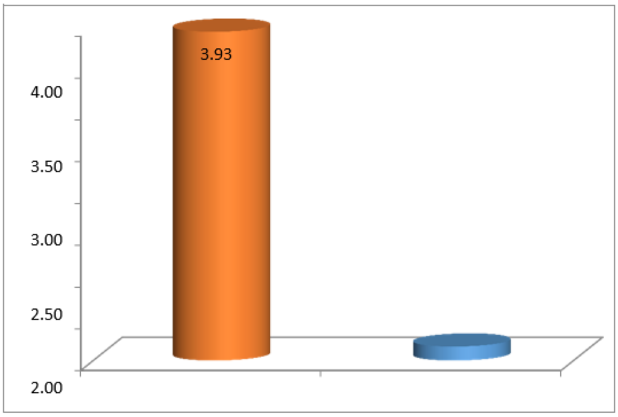

Fig. 1: Comparison of the difference in mean age (in yrs) derived by Demirijian's & Cameriere's age estimation methods wrt chronological age

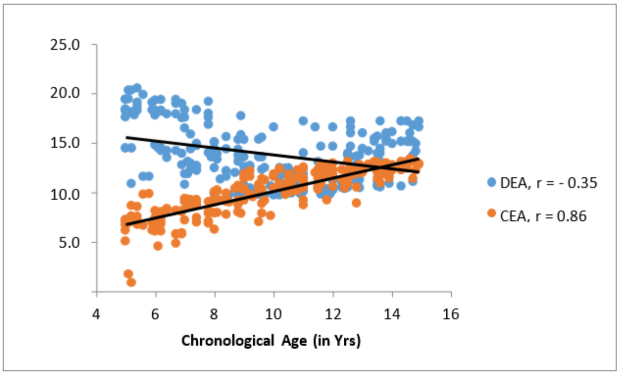

Fig. 2: Correlation between chronological age & estimated age by Demirijian's method & Cameriere's method

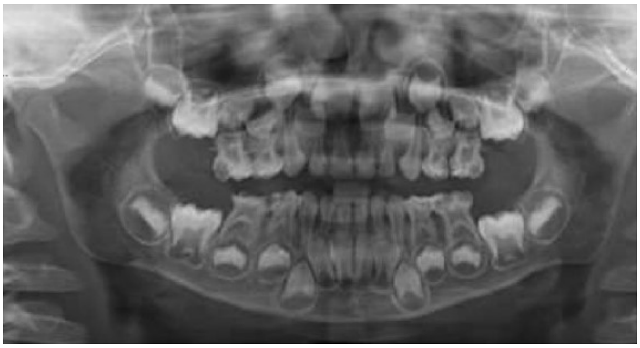

Fig. 3: Image of panoramic radiograph

Table 1: The mean prediction errors in years (ME) between the dental age (DA) by Demirijian's methodand the chronological age (CA)for each age group in females

Age Group	N	CA		DA		ME		95% of DA-CA	
		Mean	SD	Mean	SD	Mean	SD	Lower	Upper
5-5.99 yrs	12	5.25	0.27	17.23	2.59	11.98	2.54	10.37	13.59
6-6.99 yrs	12	6.39	0.37	14.73	1.47	8.34	1.58	7.34	9.35
7-7.99 yrs	12	7.20	0.17	13.12	1.70	5.92	1.70	4.84	7.00
8-8.99 yrs	12	8.32	0.37	12.03	2.03	3.71	2.10	2.38	5.04
9-9.99 yrs	12	9.33	0.27	10.84	1.26	1.52	1.31	0.68	2.35
10-10.99 yrs	12	10.35	0.26	11.28	2.01	0.93	2.10	-0.41	2.26
11-11.99 yrs	12	11.34	0.33	11.61	2.62	0.27	2.72	-1.46	2.00
12-12.99 yrs	12	12.46	0.29	13.64	2.49	1.18	2.43	-0.36	2.73
13-13.99 yrs	12	13.48	0.31	14.80	1.36	1.33	1.30	0.50	2.15
14-15 yrs	12	14.49	0.30	15.54	1.68	1.05	1.71	-0.03	2.14

Table 2: The mean prediction errors in years (ME) between the dental age (DA) by Demirijian's method and the chronological age (CA) for each age group in males

Age Group	N	CA		DA		ME		95% of DA-CA	
		Mean	SD	Mean	SD	Mean	SD	Lower	Upper
5-5.99 yrs	12	5.36	0.30	18.01	3.09	12.65	3.26	10.58	14.72
6-6.99 yrs	12	6.35	0.32	18.57	0.56	12.22	0.59	11.84	12.59
7-7.99 yrs	12	7.56	0.34	16.62	1.90	9.06	1.98	7.81	10.32
8-8.99 yrs	12	8.44	0.34	14.20	1.87	5.76	1.72	4.67	6.85
9-9.99 yrs	12	9.38	0.32	13.22	1.69	3.85	1.74	2.74	4.95
10-10.99 yrs	12	10.44	0.31	11.02	0.83	0.58	0.93	-0.02	1.17
11-11.99 yrs	12	11.43	0.34	11.61	1.41	0.18	1.46	-0.75	1.11
12-12.99 yrs	12	12.50	0.33	11.86	1.77	-0.64	1.79	-1.78	0.50
13-13.99 yrs	12	13.53	0.26	12.51	1.96	-1.03	2.03	-2.31	0.26
14-15 yrs	12	14.56	0.18	14.37	1.78	-0.19	1.77	-1.31	0.93

Table 3: Genderwise comparison of the mean age (in yrs) by Demirijian's estimated method & error wrt chronological age using student unpaired t test

Variables	Gender	N	Mean	SD	Mean Diff	95% CI of the Diff		t	P-Value
						Lower	Upper		
DEA	Males	120	14.20	3.10	0.72	-0.03	1.46	1.891	0.06
	Females	120	13.48	2.75					
DEA-CA	Males	120	4.24	5.43	0.62	-0.61	1.86	0.991	0.32
	Females	120	3.62	4.20					

Table 4: Comparison of the mean age (inyrs) betweenthe chronological & estimated methods in over-all samples using student paired t test

Variables	N	Mean	SD	S.E.M	Mean Diff	t	P-Value
Age	240	9.91	2.95	0.19	-3.93	-12.550	<0.001*
DEA	240	13.84	2.95	0.19			

Table 5: Relationship between chronological age & the Cameriere's parameters using Pearson's correlation statistics

Gender	Variable	Values	Ai	Li	Xi
		R	-0.70	0.29	-0.84
Males	Age		<0.001*	0.001*	<0.001*
			120	120	120
		R	-0.85	0.90	-0.87
Females	Age		<0.001*	<0.001*	<0.001*
			120	120	120

Table 6: Stepwise linear regression model analysis model summary

Gender	Model	R	R2	Adjusted R2	S.E.E
Males	1	0.84a	0.71	0.71	1.59
	2	0.85b	0.73	0.72	1.56
Females	1	0.90c	0.82	0.81	1.28
	2	0.91d	0.84	0.83	1.21

Table 7: Coefficients for dependent variable-age

Gender	Model		Unstd. Coefficients		t	Sig.
				Std. Error		
Males	1	Intercept	12.86	0.22	57.637	<0.001*
		Xi	-11.29	0.66	-17.121	<0.001*
	2	Intercept	13.13	0.25	52.95	<0.001*
		Xi	-9.65	0.96	-10.092	<0.001*
		Ai	-0.03	0.01	-2.339	0.02*
Females	1	Intercept	1.24	0.40	3.148	0.002*
		Li	0.07	0.00	22.84	<0.001*
	2	Intercept	4.66	0.98	4.771	<0.001*
		Ai	-0.06	0.01	-3.787	<0.001*
		Li	0.05	0.01	8.944	<0.001*

Table 8: Stepwise linear regression model for predicting the age of the Individual by using Cameriere's parameters

Regression Equation for Predicting Age for Males	Adjusted R2	P-value
Age = -9.65 * X1 - 0.03 * X2 + 13.13	0.72	<0.001*
X1 - Xi; X2 – Ai		
Regression Equation for Predicting Age for Females	**Adjusted R2**	**P-value**
Age = -0.01 * X1 + 0.05 * X2 + 4.66	0.83	<0.001*
X1 - Ai; X2 Li		

Table 9: The mean prediction errors in years (ME) between thedental age (DA) by Camereiere's method and the chronological age (CA) for each age group in females

Age Group	N	CA		DA		ME		95% of DA-CA	
		Mean	SD	Mean	SD	Mean	SD	Lower	Upper
5-5.99 yrs	12	5.25	0.27	7.32	0.52	2.07	0.63	1.67	2.47
6-6.99 yrs	12	6.39	0.37	7.31	1.16	0.92	1.11	0.21	1.62
7-7.99 yrs	12	7.20	0.17	9.03	0.31	1.83	0.38	1.59	2.08
8-8.99 yrs	12	8.32	0.37	9.64	0.65	1.32	0.72	0.86	1.78
9-9.99 yrs	12	9.33	0.27	10.52	0.89	1.19	0.97	0.58	1.81
10-10.99 yrs	12	10.35	0.26	11.03	0.81	0.68	0.91	0.10	1.25
11-11.99 yrs	12	11.34	0.33	11.62	0.78	0.28	0.79	-0.23	0.78
12-12.99 yrs	12	12.46	0.29	11.62	0.93	-0.84	1.06	-1.52	-0.17
13-13.99 yrs	12	13.48	0.31	12.26	0.34	-1.21	0.44	-1.49	-0.93
14-15 yrs	12	14.49	0.30	12.70	0.34	-1.79	0.38	-2.03	-1.55

overestimated in younger age groups which is in contrast with the studies done by Koshi et al[8] Nykamen et al,[6] Mohammad et al,[7] and Prabhakar et al.[9] The probable reason for difference may be attributed to environmental factors such as socio-economic status, nutrition and dietary habits that may vary in study population.

The difference in chronological age and dental age in our study using Demirijian's method was +2 years for the older individuals, these findings agree fairly well with other previous studies done by Hagg et al[10] and Davis et al.[11]

In the present study age estimated by Demirijian's method was more accurate in females than in males. The mean difference found in our study was 4.24 and 3.62 in males and females respectively It can be inferred that females of south Indian population are more advanced in dental and skeletal maturation than males. This is in concordance with the studies done by Eid et al[12] and Prabhakar et al.[9] This indicated that the female showed an earlier maturation in dental development than the males which can be comparable to the early maturation of skeletal

Table 10: The mean prediction errors in years (ME) between the dental age (DA) by Camereiere's method and the chronological age (CA) for each age group in males

Age Group	N	CA		DA		ME		95% of DA-CA	
		Mean	SD	Mean	SD	Mean	SD	Lower	Upper
5-5.99 yrs	12	5.36	0.30	6.40	2.75	1.04	2.60	-0.62	2.69
6-6.99 yrs	12	6.35	0.32	6.67	1.04	0.32	1.26	-0.48	1.12
7-7.99 yrs	12	7.56	0.34	7.87	0.91	0.31	1.05	-0.36	0.98
8-8.99 yrs	12	8.44	0.34	8.51	1.14	0.07	1.07	-0.61	0.75
9-9.99 yrs	12	9.38	0.32	9.85	1.66	0.47	1.85	-0.71	1.65
10-10.99 yrs	12	10.44	0.31	11.11	0.72	0.67	0.78	0.17	1.16
11-11.99 yrs	12	11.43	0.34	11.10	1.41	-0.34	1.29	-1.16	0.48
12-12.99 yrs	12	12.50	0.33	11.91	1.00	-0.59	0.97	-1.21	0.02
13-13.99 yrs	12	13.53	0.26	12.21	0.70	-1.33	0.81	-1.84	-0.82
14-15 yrs	12	14.56	0.18	12.83	0.53	-1.73	0.54	-2.08	-1.39

Table 11: Genderwise comparison of the mean age (in yrs) by Cameriere's estimated method & error wrt chronological age using Student unpaired t test

Variables	Gender	N	Mean	SD	Mean Diff	95% CI of the Diff		t	P-Value
						Lower	Upper		
CEA	Males	120	9.84	2.58	-0.46	-1.04	0.12	-1.555	0.12
	Females	120	10.30	1.97					
CEA-CA	Males	120	-0.11	1.55	-0.56	-0.94	-0.17	-2.858	0.005*
	Females	120	0.44	1.46					

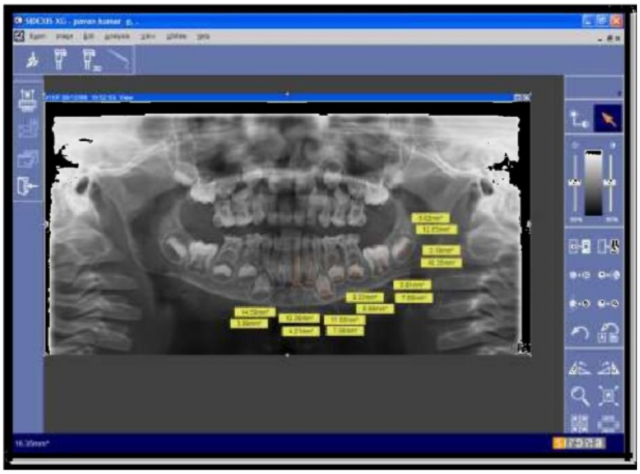

Fig. 4: Measurements of distance between the inner side of the open apex (Ai) and tooth length (Xi)

age also seen in females. The results were in contrast with the study done by Landera et al[13] which might due to different geographical location, uneven sample size and distribution.

The overall findings of Demirijian's age estimation in the present study reveal that the dental age was overestimated when compared to chronological age in all the age groups studied, which did not vary significantly with age, although there was a slight tendency towards greater overestimation in younger children which was similar to the studies conducted by Koshi et al,[8] Prabhakar et al,[9] Nykamen et al,[6] Eid et al.[12] Liversidge et al[14] at the belief that the overestimation in dental age in recent findings using Demirjian's method in different populations may be partly explained by a positive secular trend in growth and development during the last 25 years. Nystron et al suggested that difference in overall dental maturity reflects on their dental estimated age which exist not only between the nation, but also between groups of children in a nation with a relatively homogenous population.

The present study conducted by using Cameriere's method is based on seven mandibular left healthy permanent teeth for assessing dental age by measurement of open apices in teeth. Statistical analysis showed a significant correlation with chronological age, morphological variables R2 =0.83 with p value <0.001 which was in correlation with the study done by Cameriere et al[3] on Italian population 83.6% (R2=0.836).and also with a study done by Rai et al.[15] (R2= 0.89).

In the present study, using Cameriere's method the maximum accuracy was seen in age group of 8-9years in males and 11-12 years in females which was in agreement with the study done by Cameriere et al. 2012.[2] The maximum accuracy was seen in middle age groups, these findings are in accordance with the Cameriere et al 2006[3] and Cameriere et al. 2007.[16] The significant decrease in accuracy in the oldest age cohort depends on many variables, but may particularly be attributed to the almost complete maturation of the teeth in this age cohort.

With comparison to gender, the mean DA was overestimated by 0.44 year with the mean differences of

0.28 to 2.07 years in females and with p value <0.001. For males, the mean DA was underestimated by −0.11 with the mean differences of −0.59 to 1.04 years which was in agreement with Rai et al,[15] Galic et al.[17] It is attributed to the possibility that the poor nutritional status of Indian adolescents, especially girls, has important implications in terms of their capacity for physical work and adverse reproductive outcomes, as was in fact observed in one study. Hence, the maturation of females and males may be said to occur at about the same time because the early maturation of females, when compared with males which may be due to the offset by malnutrition and the greater amount of physical work required of them. Hence it indicate that more attention should be focused on the possible differences between children of different origins. These findings are in contrast with the study done by Cameriere et al[3] where the study was done on Caucasian children using European formula. So, probably the original Cameriere's regression equation cannot be applied to Indian populations. Hence, a new equation shall be required to suit the Indian population. The overall results shows that the Cameriere estimated age is accurate in all the age groups with a minimum mean difference of 0.17 years which was in accordance with the previous studies done by Cameriere et al. 2006,[3] Cameriere et al. 2007[16] Rai et al 2011,[15] Cameriere et al 2012,[2] Galic et al.[17] Cameriere's technique is very accurate and represents a useful method for age assessment in children of this age group (5–15 years). The accuracy of age estimation indicates how well chronological age can be predicted, and greater accuracy can be obtained by choosing the method which shows the least variability with age.

The results of the present study showed that the Cameriere's age estimation method using open apex is more accurate when compared to Demirijians age estimation with the mean difference of 3.93 in Demirijian's and 0.17 in Cameriere's method. The observed versus predicted plot fitted well in Cameriere's than in Demirijian's method. This was in agreement with previous studies Rai et al 2006,[15] Cameriere et al 2007.[2] Statistical analysis indicated that morphological variables explain 35% (R2 = 0.35) of variations in estimated chronological age using Demirijian's method which was in contrast with the study done by Landera et al[13] which might due to different geographical location, uneven sample size and distribution and Cameriere's method explain 86% (R2 = 0.86) of variations in estimated chronological age which is in accordance with the previous studies done by Cameriere et al. 2007[2] and Rai et al. 2011.[15]

5. Conclusion

The present study shows that the dental maturity correlates with the chronological age and both the Cameriere's and Demirijian's method can be used for accessing biological age in which Cameriere's method of age estimation was found to be more accurate when compare to Demirijian's method.

Further, studies or research should be done aiming at acquiring even more large sample sizes in order to reduce standard errors of estimates and also at investigating the effect of race and culture in the model parameters.

6. Conflict of Interest

None.

7. Source of Funding

None.

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Author biography

Aparna Srivastava, Consultant

Poornima Govindraju, Professor https://orcid.org/0000-0001-9121-8627

Balaji Pachipulusu, Professor and Head

Mahesh Kumar T S, Reader

Cite this article: Srivastava A, Govindraju P, Pachipulusu B, Kumar T S M. Comparative assessment of Demerijian's and Cameriere's dental age estimation in children - A panaromic radiographic study. *J Oral Med, Oral Surg, Oral Pathol, Oral Radiol* 2022;8(2):61-68.