

Comparison of the validity of two dental age estimation methods: A study on South Indian population

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Abstract

Background: Forensic odontologists are often confronted with the problem of estimating age for the identification of unknown bodies or skeletal remains of accidents, crimes and disaster victims. Teeth have the benefit of being preserved long after other tissues have disintegrated and present the only means for age estimation. Different techniques have been published for dental age estimation with variable accuracy, precision and reliability. The search for optimal method by forensic odontologists has continued over the years until the present day. **Aim:** The present study was aimed at evaluating and comparing the accuracy of age estimation using translucent dentin and cemental annulations. **Materials and Methods:** A total of 150 freshly extracted teeth were obtained and longitudinal ground sections were prepared. The length of the translucent dentin was measured and cemental annulations were counted in each section and the age was calculated separately for both the methods. **Results and Conclusion:** The present study suggests that both the methods are reliable in the middle age groups; whereas the large error obtained in the extreme age groups indicate that translucent dentin method should be preferred in older age group and cemental annulations method in the younger age group before the formation of translucent dentin.

Key words: Age estimation, cemental annulations, translucent dentin

Introduction


Age estimation is a sub discipline of the forensic sciences and is an important part of every identification process, especially when information relating to the deceased is unavailable. The estimation should be as accurate as possible since it narrows down the search for the individual

among missing. Accurate estimated age helps the search and enables a more efficient and time saving approach to individual identification.^[1]

Various age estimation techniques have been proposed using different skeletal and dental tissues. Dental age estimation methods are either based on the well-ordered cascade of changes that occur during the formation and eruption of teeth or rely on continuous processes that alter the quality of dental tissues even when individual growth is completed. The accuracy of age estimation in individuals below 15 years is much greater compared with adults, due to the presence of a multitude of developing teeth.^[2,3] However ambiguity regarding the best method of adult age estimation still persists.

Dentin and cementum are the only hard substances of the tooth, which are continuously synthesized and

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maintained throughout all stages of an individual's adult life. These gradual and lifelong changes make dentin and cementum ideal tissues for the study of aging process. It has been demonstrated that they can provide valuable information for the estimation of age.^[2,4] Various methods have been employed for dental age estimation using dentin translucency and cemental annulations separately. However, there are only few comparisons of these methods available, especially an analysis which compares the accuracy of age estimation using the quantification of tooth cementum annulations and length of dentin translucency in the same tooth specimen is still lacking. It was the aim of the present study to evaluate and compare the performance of two dental age estimation methods i.e., dentin translucency and cemental annulations and to analyze their accuracy in individuals of different age groups.

Materials and Methods

The study was conducted on 150 single rooted teeth, collected from the Department of Oral and Maxillofacial Surgery, College of Dental sciences, Davangere. The age and sex of the patients from whom teeth were extracted was noted along with the reason for extraction and the informed consent was obtained after explaining the purpose of the study. For a wide representation of age, groups were subdivided based on different age groups with a minimum of twenty-five teeth in each group [Table 1].

Inclusion criteria

- Single rooted teeth extracted for therapeutics reasons from patients aged between 15 and 75 years.

Exclusion criteria

- Hypercementosis, chronic periodontitis
- Teeth extracted from orthodontically treated cases
- Endodontically treated teeth
- Teeth with history of trauma
- Teeth associated with cysts and tumors.

Immediately after extraction, the teeth were rinsed in normal saline solution. They were then preserved in 10% neutral formalin until ground sections were made. Each tooth was embedded in acrylic and axio bucco-lingual sections of 150 μ m thickness were prepared using hard tissue microtome [Figure 1]. The sections were then dehydrated and

mounted on glass slides and cover slips placed over them. They were then observed under both light and stereomicroscope.

Estimation of age using apical translucent dentin^[5]

Mounted sections were observed under stereomicroscope and were photographed. The length of apical translucent dentin (T) was measured using the image analysis software after calibration. Modified Bang and Ramm's formula specific for Indian population was applied to all measurements and the age of the individual was estimated [Figure 2].

T = Length of apical translucent Dentin

Linear regression:

- If $T \geq 9$ mm
 - Age = 35.5619+ (3.4828 \times T).

Quadratic regression:

- If $T \leq 9$ mm
 - Age = 29.9074+ (7.4507 \times T) + (-0.4369 \times T²).

Estimation of age using cemental annulations^[6]

In each section, area at the junction of apical and middle third of the tooth root, an area where the lines seem to be running approximately parallel was selected and photographed.

The width of the cementum (X) from Dentino cementum Junction to the surface of the cementum was measured. Measurement of width occupied by the two adjacent incremental lines (Y) was made [Figures 3 and 4]. Then the number of incremental lines (N) in the total cementum width was calculated using the formula:

$$N = X/Y$$

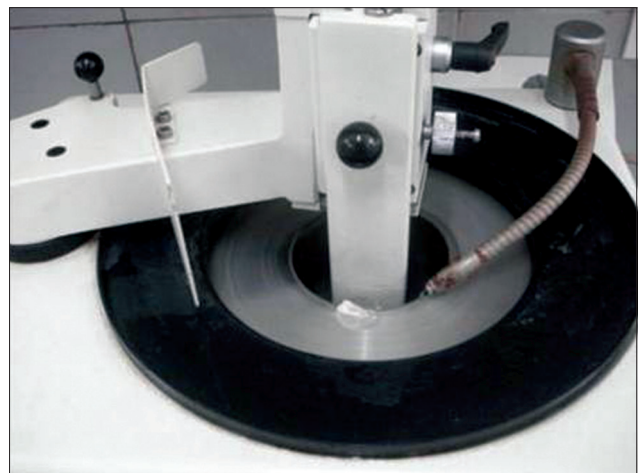


Figure 1: Photograph showing sectioning of tooth mounted in acrylic block using hard tissue microtome

Table 1: Study groups

Group	Age (in years)	Number of teeth
I	15-25	25
II	26-35	25
III	36-45	25
IV	46-55	25
V	56-65	25
VI	66-75	25

The age of the individual (E) was estimated by adding average eruption age (T) in years of each tooth with the numbers of increment lines (N).

$$E = N + T$$

Mean of chronologic, estimated age of both methods were calculated. The difference between mean chronological age and estimated age was calculated individually for both the methods. Group-wise difference between the mean chronological age and estimated age was calculated for both the methods. The data obtained were compared using Paired *t*-test. Pearson correlation coefficient was found.

Results

Age estimated using translucent dentin (method I) [Tables 2,3 and 4, Graph 1]

The overall mean difference between chronological age and estimated age of 150 teeth was 5.6 with a standard deviation (SD) ± 4.2 years. The estimated age was found to be approximately 5.6 years above the chronological age and the difference was found to be statistically significant ($P < 0.001$).

Age estimated using cemental annulations (method II) [Tables 3 and 4, Graph 2]

The overall mean difference between chronological age and estimated age of 150 teeth was 2 with a SD ± 5.6 years. The estimated age was found to be approximately 2 years below the chronological age and the difference was found to be statistically significant ($P < 0.001$).

Comparison of two methods of age estimation (Method I and Method II) [Tables 3 and 5]

Paired *t*-test was performed to compare the results of both the methods and a statistically significant difference was found between the age estimated using method I and method II ($P < 0.001$). The correlation coefficient of method I and II were 0.97 and 0.98 with percentage correlation of 94% and 96% respectively. The standard error of method I and II were 4 and 3.6 years respectively.

Table 2: Age estimated using translucent dentin

Group	Age in years	Chronological age in years	Estimated age in years	Mean difference of chronological age and estimated age
I	15-25	19.4	29.9	10.5
II	26-35	29	35.6	6.7
III	36-45	42.4	48.3	5.9
IV	46-55	51.2	57.7	6.5
V	56-65	59.8	63.2	3.4
VI	66-75	68.6	69.4	0.7

Discussion

Age estimation is crucial to the identification process of unknown missing people. It also provides valuable

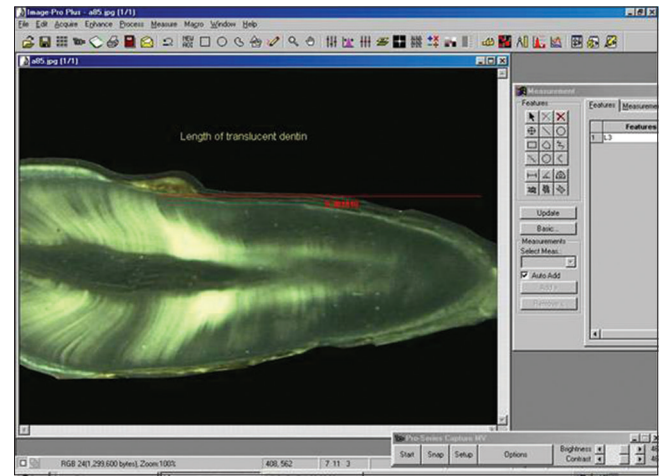


Figure 2: Photograph showing translucent dentin under stereomicroscope ($\times 7$)

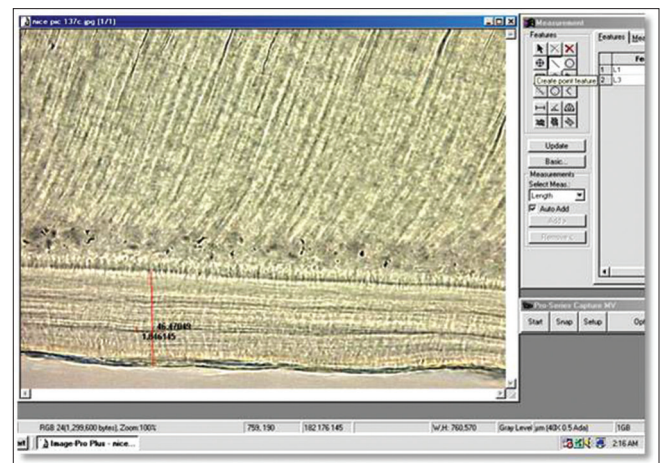


Figure 3: Photograph showing cemental annulations under light microscope ($\times 10$)

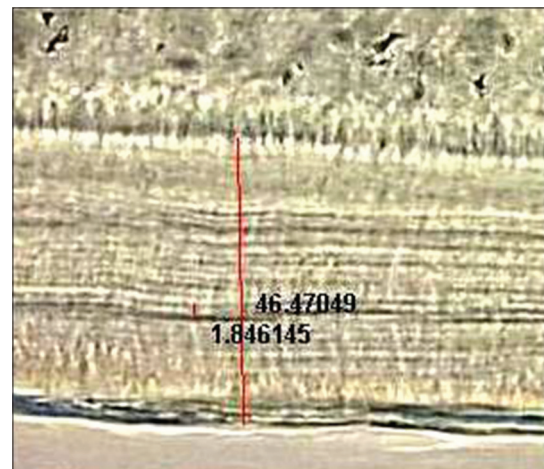


Figure 4: Photograph showing enlarged image of cemental annulations

Table 3: Mean, SD and range of method I and II and errors in estimated age

Particulars	Chronological age in years	Estimated age method I	Estimated age method II	Errors in estimation		
				Mean difference chronological age-estimated age by method I	Mean difference chronological age-estimated age by method II	Mean difference method I-method II
Mean±SD	45.1±17.2	50.7±14.8	43.1±12.9	-5.6±4.2	2±5.6	7.6±4.3
Range (years)	17-75	30-80	21-65	7-19	7-14	1.4-19
% variation				-12.40	4.40	15
t value				16.4	4.28	21.5
Significance				P<0.001	P<0.001	P<0.001

SD: Standard deviation

Table 4: Age estimated using cementum annulations

Group	Age in years	Chronological age in years	Estimated age in years	Mean difference in chronological age and estimated age
I	15-25	19.4	24.2	4.8
II	26-35	29	30.1	1.2
III	36-45	42.4	41.8	0.6
IV	46-55	51.2	49.3	1.9
V	56-65	59.8	54.2	5.1
VI	66-75	68.6	57.6	11.1

Table 5: Correlation between chronological age and estimated age using method I and II

Correlation between	r	P	r ² %	Standard error
Chronological age α estimated age using method I	0.97	<0.001	94	4
Chronological age α estimated age using method II	0.98	<0.001	96	3.6

information in the paleodemographical analysis of ancient skeletal remains.

Dental age estimation methods are either based on the highly ordered cascade of changes that occur during the formation and eruption of teeth or on the continuous processes that alter dental tissues thereafter.^[7] The gradual and constant changes occurring in dentin and cementum make them ideal tissues for the study of the aging process. The methods which use them for age estimation, such as the methods used in this study are considered the most reliable methods of age estimation.

In the present study, a strong correlation between length of translucent dentin and cemental annulations with the advancement of age is found. There is also a definite and gradual increase in the dentin translucency and cemental apposition with age. These findings are supported by various previous reports.^[4,5,8,9]

The translucent dentin method in this study yielded a coefficient correlation of 0.97 in comparing the calculated age with the actual age. Singhal *et al.*^[4] had obtained the same value in their study, while other researchers had obtained different values but similar results.^[5,10]

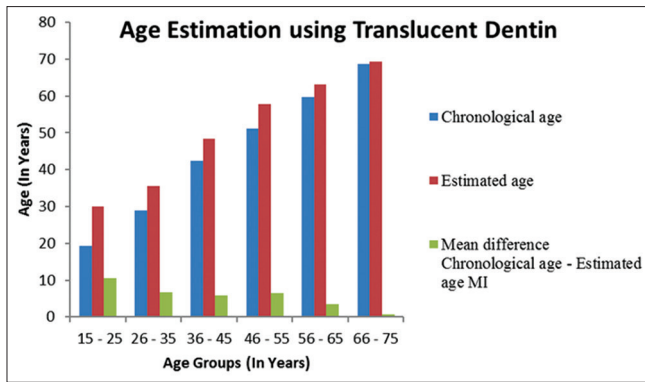
The difference between mean chronological and mean estimated age for 150 teeth using translucent dentin method is 5.6 years in the present study; a value considered to be acceptable^[5] and lower than that reported by Acharya and Vimi^[5] and Bang and Ramm^[10]. The greater accuracy of the present study in age assessment was achieved by equal and uniform distribution of individuals of different ages in the sample and inclusion of only a single tooth from each subject.

Age estimation using translucent dentin method shows highest mean age difference of 10.5 years in the age group of 15-25 years. Translucent dentin formation usually starts above the age of 20-30 years^[8] and as such, no translucent dentin was found in this age group. Thus, the method does not seem to hold good for this age group. However, contradictory to the above finding, Vasiliadis *et al.*^[11] and Bang and Ramm^[10] have found translucent dentin formation below the age of 20 years in their study group. The minimum age, which can be calculated by using modified Bang and Ramm formula, is 29.9 years, making its application for a younger age inappropriate. The mean age difference of 6.7, 5.9 and 6.5 years in the middle age groups such as 26-35, 36-45, 46-55 years respectively suggests that the translucent dentin method is reliable in these age groups.

Older age groups of 56-65 and 66-75 years showed the least variation of 3.4 and 0.7 years respectively. The reduction in error value may be caused by reduced rate of formation of translucent dentin which could be nearing the amount of increase 0.13-0.287 mm, necessary for the calculated age to increase by 1 year using this formula.

In the present study, the correlation coefficient of age estimated with the actual age using cemental annulations method is 0.98, with the mean age difference of 2 years, which is similar to previous studies by Wittwer-Backofen *et al.*,^[9] Avadhoot *et al.*^[12] and Charles *et al.*^[13]

Age estimation using cemental annulations method shows a mean age difference of 4.8 years in younger age group ranging from 15 to 25 years. Middle age groups such as 26-35, 36-45, 46-55 and 56-65 years has shown mean age difference of 1.2, 0.6, 1.9, 5.1 years



Graph 1: The chronological age, estimated age and mean difference between chronological age and estimated age by translucent dentin

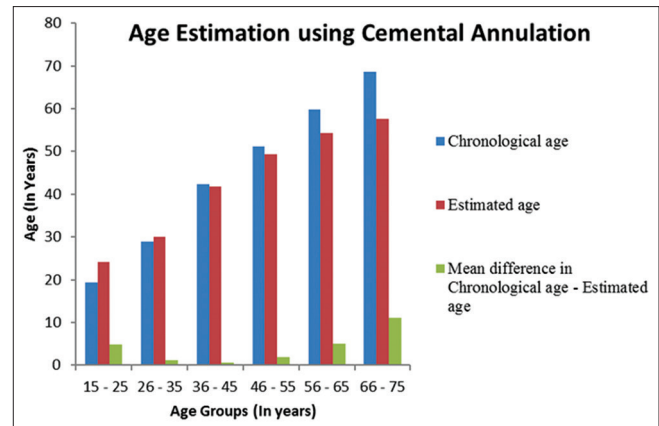
respectively. Highest difference of 11.1 years is found in the older age group ranging from 66 to 75 years. This is in agreement with previous studies which considered reduced cementum apposition in old age to be the basis for the increase in error in those age groups.^[8,14] On other hand Condon *et al.* attributed this difference to the reduction of masticatory forces in old age.^[15] This theory was discarded after the demonstration of cemental annulations in impacted teeth, which have never taken part in mastication.^[16]

The correlation coefficients of estimated age with the actual age using translucent dentin method and cemental annulations method are 0.97 and 0.98 respectively, indicating that both methods are comparable and cemental annulations method has a marginally better accuracy compared to translucent dentin method.

A number of methods have been employed for dental age estimation using dentin translucency and cemental annulations separately. However, there are only few comparisons of the methods available, especially a study which compares the accuracy of age estimated by the two methods in the same tooth specimen is still lacking. The present study evaluated the performance of dentin translucency and cemental annulations in the same tooth specimen overall and in different age groups.

The modified Bang and Ramm formula used in the present study for estimation of age using length of translucent dentin could estimate a minimum age of 29.9 years. Thus, its use in studying samples obtained for those < 30 years is inappropriate and this should be considered in the future studies during age estimation using translucent dentin method.

Further research concerning the mechanism of formation of cemental annulations and translucent dentin would be of great benefit in understanding the inaccuracy of these methods in age estimation of extreme age groups.



Graph 2: The chronological age, estimated age and mean difference between chronological age and estimated age by cementum annulation

Conclusion

In the present study, cemental annulations method was marginally better as the mean error obtained was comparatively less than that of the translucent dentin method.

This study also found both methods to be reliable in age estimation of individuals closer to middle age. Their accuracy however was considerably reduced in the extremes of life (very young and aged). Based on our findings, the translucent dentin method is more reliable in older age group and cemental annulations method in the younger age group. Where the age of the individual is unknown as would be the case in exfoliated teeth or in teeth being examined postmortem, the choice of appropriate method can be made by the presence or absence of translucent dentin in the tooth. In all cases where translucent dentin is absent age estimation by cemental annulations is to be preferred.

It is thus equally crucial to choose the appropriate method for the specific age group, since the accuracy of the techniques varies considerably with varying age of the subject.

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