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Age estimation using radicular dentine transparency: A new innovative approach

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Abstract

Aim: To estimate the age of the individual from radicular dentine transparency and to derive a formula suitable for age estimation in the Indian population, using radicular dentine transparency. **Materials and Methods:** Seventy teeth samples of known age were collected from patients belonging to different age groups ranging from 11 to 80 years whose teeth were extracted for various therapeutic purposes. The samples were grouped from A to G according to their age, each group consisting of 10 teeth samples. Buccolingual sections of 100 μm thickness were obtained using hard tissue microtome. The sections were scanned using a flat-bed scanner. The scanning base of the scanner was pasted with a graph sheet and the teeth samples pasted on to the graph sheet were scanned with a resolution of 600 dpi, and the images were stored in a computer. The graph sheet was clearly visible in the area of transparent dentine, and the length of transparent dentine (i.e., the number of millimeters on the graph) was measured from the scanned images, stored in the computer. **Results:** A strong positive correlation between age and transparency of dentin was noted. The age was estimated with an accuracy of ± 5 years (61.4%) and ± 10 years (12.9%). The present study had a level of agreement of 71.4% with that of Bang and Ramm. **Conclusion:** Thus, transparency level of the radicular dentin increases with age, and it can be used as a single reliable parameter for age estimation.

Key words: Age estimation, Bang and Ramm criteria, radicular dentin transparency

Introduction

The identification of dental remains is of key significance in cases where the body of the deceased person is decomposed, skeletonized, or burnt. The main advantage of dental evidence is that it is frequently preserved after death and not affected by adverse conditions.[1] Age is a primary factor crucial for preliminary screening procedures. Age estimation has been used successfully for identification and treatment purposes. It has been helpful in cracking criminal cases, in establishing the authenticity of legal documents such as birth certificates, marriage certificates, and other official documents. Among the time-honored dental parameters used for estimating age, root dentin transparency (RDT) is considered to be a stable parameter not affected by environmental cum pathological factors and is considered to be the most reliable criteria established till date.[2] Transparency starts in the apical part of root and increases with age in the coronal direction. This particular change is least affected by environmental factors and pathological

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processes. It also shows symmetrical distribution on both sides of jaws. Using RDT as a single parameter, Bang and Ramm[3] in 1970 embellished an approach and formulae for predicting age in Norwegians and reported that there is a significant increase in root transparency with age. Following the method of Bang and Ramm,[3] an attempt has been made in this study to derive a formula specific for establishing the age of the Indian population.

Materials and Methods

After obtaining institutional ethical clearance, seventy teeth samples of known age were collected from patients belonging to different age groups ranging from 11 to 80 years whose teeth were extracted for various therapeutic purposes. Only one tooth sample from an individual was collected. The teeth collected include incisors, canines, premolars, and molars [Table 1]. The teeth samples were divided into seven different groups from A to G, according to their age group, with 10 samples in each group. Before extraction, the name, age, sex, and tooth number of the patient were recorded. Following extraction, the extracted teeth were stored in 10% neutral formaldehyde (formalin) solution. Later, the teeth samples were dried and mounted on acrylic autopolymerizing media (self-cure resin) into a cylindrical-shaped structure for facilitating access and easy sectioning of tooth. All mounted sections were given a code number according to the age group which they belong to and later subjected to sectioning using Hard-Tissue Microtome (Leica Microsystems Nussloch GmbH, Germany). Buccolingual sections of 100 µm thickness were obtained from the center of the teeth or near to the center of the teeth. Later, the sections were scanned using a flat-bed scanner-Cano-Scan-Lide-110. (Cano-Scan-Lide-110) The scanning base of the scanner was pasted with a graph sheet and the teeth samples pasted on to the graph sheet were scanned with a resolution of 600 dpi, and the images were stored in a laptop-Hewlett Packard Envy (Hewlett Packard Developmental Company, LP, USA).

The translucency of the teeth (T) was measured from the apex to the coronal direction up to the borderline formed between the transparent dentine and opaque dentine by counting the graph-sheet lines which were clearly visible through the transparent dentine of the sectioned tooth sample. If the borderline or junction between the transparent dentine and opaque dentine is not clearly discernible as a relatively horizontal line then both the minimum (T_1) and the maximum (T_2) extension of translucency was measured. In cases where the junction was depicted as a fairly even horizontal line or situations where translucency could be appreciated only on one side (i.e., buccal or lingual), only one measurement was taken as transparency level (T) [Figure 1]. The mean value (Tm= [T_1 + T_2]/2) was recorded as the transparency level if there were different levels of transparency visible in the buccal and lingual aspect of the tooth section [Figure 2]. If a distinct zone of cementum was discernible at the tip of the root apex on the longitudinal sections, it was not included in the translucent root length. Following this, the sections were decoded. The age was calculated using specific regression equations developed statistically to obtain formulas specific for Indian population using SPSS 17.00. The actual age (a), estimated age (A), difference between two (a-A), translucency mean (Tm), and Standard deviation (SD) values were tabulated using MS Office Excel Spreadsheet (Microsoft Corp. Redmund, Washington, USA). The estimated age of the present study was compared with the age obtained by subjecting the measurement of root dentine transparency in the study samples to the regression constants obtained by Bang and Ramm.[3]

Table 1: Distribution of samples according to tooth type

Tooth type	Frequency (%)
First molar	3 (4.3)
First premolar	20 (28.6)
Second molar	3 (4.3)
Second premolar	6 (8.6)
Third molar	1 (1.4)
Canine	5 (7.1)
Central incisor	18 (25.7)
Lateral incisor	14 (20)
Total	70 (100)

Results

The results were obtained using SPSS version 17.00 statistical software programme (SPSS Inc., Chicago, Illinos, USA). Out of the total 70 teeth sample's collected, 38 teeth samples were of females and 32 were of males. The minimum age was 13 years and maximum was 80 years. The mean age was estimated to be 45.543 with a SD of 20.0446. The minimum transparency observed was zero (0 mm) and maximum level was 10 mm. The average transparency level for each group was obtained. The least level of transparency was noted in Group A (11–20 Years)

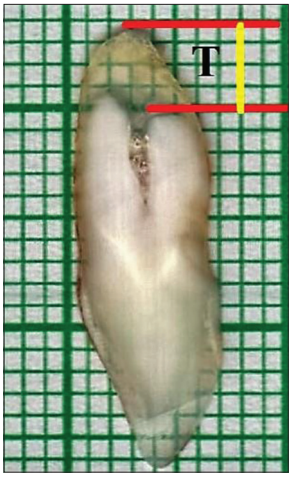

Figure 1: Translucency (T) seen in radicular dentine

measuring 1 mm and the maximum level was 8 mm in Group G (71–80 Years) [Table 2]. Pearson's correlation obtained showed that age and transparency were positively correlated which was significant at 0.01 level [Table 3]. The regression coefficients were obtained statistically as shown in Table 4, and the formulae for age estimation in Indian population was derived. The linear regression line obtained shows that both age and transparency levels were well correlated [Figure 3]. Ninety-five percent confidence interval derived shows that if ever the study is carried out in a different population of different ethical origin, the constants can be within the following limits. Where B_0 (26.64) can vary from 20.797 to 32.483 and B_1 (5.293) can vary from 3.973 to 6.612.

Formulae obtained for age estimation:

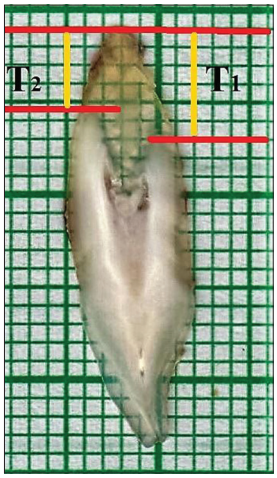

Figure 2: Mean transparency (Tm) = (T1+T2)/2

Table 2: Average transparency obtained in each group

Age group	Average transparency level (mm)
Group A (11-20)	1
Group B (21-30)	2.5
Group C (31-40)	4
Group D (41-50)	4.5
Group E (51-60)	5
Group F (61-70)	6
Group G (71-80)	8

Table 3: Pearson's correlation between age and transparency level

Variables	Pearson correlation value	Significance (*P*)
Age versus transparency	0.697	<0.01

$$Age = B_0 + B_1X$$

Where, B_0, B_1, are constants and X is measure of transparency.

Substituting the values for B_0 and B_1, obtained from the present study, the formulae derived for age estimation in South Indian population is as follows:

Formulae for age estimation in Indian Population:

Age = 26.64 + 5.293 (T) (T = Transparency).

The difference between the known age and the predicted age was obtained [Table 5]. The difference in estimated age of 43 /70 (61.4%) samples was <5 years and 9/70 (12.9%) samples was <10 years. The Box and whisker plot a quantitative graphical representation elucidates the degree of variation between the known age and estimated age [Figure 4]. The lower limit for the known age is 14 and the upper limit is 80, whereas for the estimated age, the lower limit is 27 and the upper limit is 78 years. The range (shaded area) for the known age is from 23 to 62 years, whereas for the estimated age is from 37 to 53 years. The median (black line within the shaded area) for the known age is 48 years and for the estimated age is 43 years, more or less the median has similar value, suggesting that only minimal variation was noted between the known age and estimated age.

The linear regression coefficient was obtained (r = 0.679; r^2 = 0.485) and was significant at the level of <0.01 [Table 6 and Figure 3]. The difference between the estimated age and chronological age obtained from the present study (A) and the age obtained by substituting coefficients obtained from Bang and Ramm[3] (B) study in the same sample were done [Table 7] and the results obtained were statistically inferred using Kappa statistics [Table 8]. The relationship between the present study and Bang and Ramm's study is represented using cross tabulation [Table 7]. The predicted age of 29/70 cases is in agreement between the present study and Bang's study, as shown in cross tabulation category-1. Similarly, 31/70 cases are in agreement with each other in cross-tabulation category 2. Thus, 60/70 (i.e.,29 + 31 = 60) cases are in agreement between the present study and Bang and Ramm's study. Similarly, 10/70 cases were not in agreement between the present study and Bang and Ramm's study. The measure of agreement bet. These values were statistically inferred using Kappa statistics [Table 8]. The present study and Bang and Ramm had an agreement of value up to 71% (0.714) [Table 8].

Table 4: The regression coefficients

Model	Unstandardized coefficients		Standardized coefficients	*t*	Significance	95.0% CI for B	
	B	SE	Beta		*P*	Lower bound	Upper bound
B_0	26.64	2.928	0.697	9.098	<0.01	20.797	32.483
B_1	5.293	0.661		8.005		3.973	6.612

CI: Confidence interval, SE: Standard error

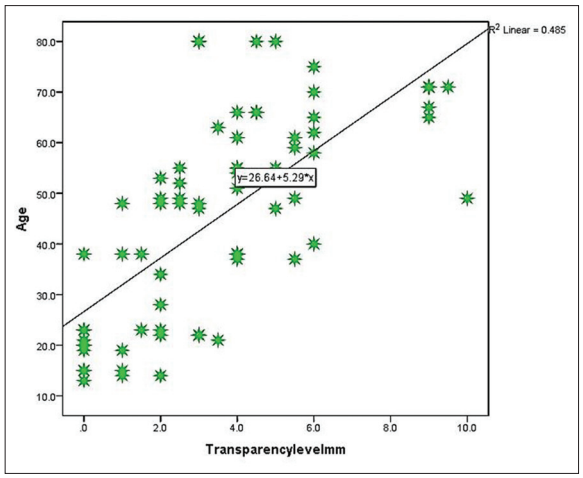

Figure 3: Linear regression line

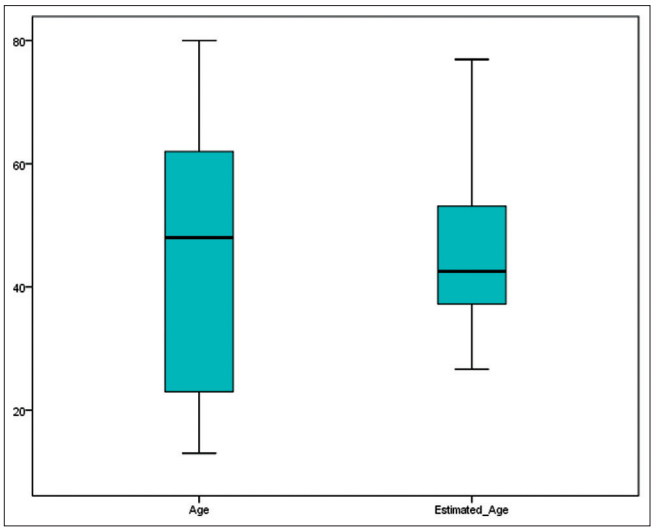

Figure 4: Box and Whisker plot diagram

Discussion

There is increasingly strong evidence that dentine transparency is directly proportional to the increase in age and thus would serve as a reliable tool to aid the purpose of age estimation in both living and the dead. The measurement of dentine transparency in both intact and sectioned tooth with different thickness levels has been reported by Miles,[4] Bang and Ramm,[3] and Thomas *et al*.[5] It is also clear that transparency starts from the apical region and extends coronally.

A relatively simple and inexpensive method for age determination in adults by means of measuring the length of root transparency on intact and/or on longitudinal sections of root was presented by Bang and Ramm.[3] It is one of the most comprehensive on the topic and assessed 926 teeth samples comprising of 978 roots. Both intact and sectioned teeth were used with no apparent differences in terms of correlation to age; however, it was observed that sections offered better detail for examination. Thus, the present study was done in Dravidian population to estimate the age of an individual from RDT using formula that was developed statistically.

In the present study, there was a straight line relationship between age and transparency, which reaffirms that there is definitely a positive correlation between age and root dentine transparency. A Pearson's correlation value of 0.697 with a significance of <0.01 was obtained, which also signifies that there is increase in RDT with increase in age. The minimum or least measured value of RDT in the present study was zero mm, which was more pronounced in Group A (11–20 years) and Group B (21–30 years). The highest transparency value measured was 10 mm belonging to Group G (71–80 years). The present study had a linear regression coefficient value of $r = 0.69$, which was significant with a $P < 0.01$ level [Table 4]. The regression coefficient of the present study ($r = 0.69$) is in agreement with Bang and Ramm[3] ($r = 0.70$), Solheim and Sundnes[6] ($r = 0.76$), Thomas *et al*.[5] ($r = 0.59$), and Kattapagarei *et al*.[7] ($r = 0.77$). Studies that have reported higher regression coefficients compared to that of the present study ($r = 0.69$) include Singhal *et al*.[8] ($r = 0.81$) and Sabarad *et al*.[9] ($r = 0.97$). Studies conducted by Foti *et al*.[10] ($r = 0.36$), Valenzuela[11] ($r = 0.38$), and Singh *et al*.[12] ($r = 0.46$) have lower regression values compared to the present study ($r = 0.69$). The variation could be attributed to variation in sample size

Table 5: Difference between the known age and predicted age

Age difference (years)	Frequency (%)
<5	43 (61.4)
5-10	9 (12.9)
10-15	6 (8.6)
15-20	8 (11.4)
>20	4 (5.7)
Total	70 (100)

Table 6: Values for linear equation

Equation	Model summary			Parameter estimates	
	R	R^2	Significance (*P*)	Constant B_0	Constant B_1
Linear	0.679	0.485	<0.01	26.64	5.293

Table 7: Cross tabulation showing predicted values of the present study and Bang and Ramm's coefficient

A-predict × B-predict cross tabulation (count)			
A-predict (present study)	B-predict (bang's study)		Total
	1	2	
1	29	6	35
2	4	31	35
Total	33	37	70

Table 8: Measurement of agreement between the present study coefficient and Bang and Ramm's coefficient

Symmetric measures		
Measurement of agreement	Value	Approximate significance
κ	0.714	<0.01
Total (*n*)		70

and population studied. In this study, 74.3% of the estimated age had a difference of <10 years from the actual age and (61.4%) majority of the sample size fell under the category of <5 years of age difference. Solheim and Sundnes,[6] Solheim and Vonen[13] considered errors <±10 years as "acceptable" in forensic age estimation. Schmeling *et al*.[14] categorized age estimation methods that produce mean errors of 6–8 years as "moderately good." Furthermore, in our study, 6/70 (8.6%) samples fell under the category of <10–15 years of age difference, 8/70 (11.4%) under the category of <15–20 years, and 4/70 (5.7%) under the category of >20 years of age difference. This could be because of inclusion of 20/70 teeth samples belonging to the second and third decade. As the literature states transparent dentine formation occurs only after the third decade of life. A similar study was done by Bang and Ramm[3] in Norwegian population in the year 1970. The present study and Bang and Ramm[3] had an agreement of value up to 71% (0.714) [Tables 7 and 8]. 60/70 (85.71%) (i.e., 29/70 and 31/70) had similar prediction between the present study and Bang and Ramm.[3]

Many studies have used custom-made software American Board of Forensic Odontology No. 2 scale (Tritech Forensics, Phoenix, AZ, USA) on the scanner platen, stereomicroscopy, and digital Vernier caliper measurements to measure the root dentine transparency level. The measuring method used in the present study is very simple and does not require complicated software usage. The present study is a combination of both digital and conventional method.

The present study used buccolingually sectioned teeth of 100 μm thickness. There are studies reported to have used 500, 400 and 250 μm thick sections. Studies using intact teeth were also done by Bang and Ramm[6] and Drusini *et al*.[15] It has been reported that sectioned samples provide a better detail for measurement.

The study also shows that the progression of the level of translucency with advancing age is not uniform – there is a tendency for it to slow down as age advances, particularly after 60 years. Bang and Ramm[3] made similar observations and believed that most of the root becomes translucent as age advances, beyond which further increase in translucency is impeded. Furthermore, it appears that rate of translucency begins to decrease after ~60 years of age. This was noted by Bang and Ramm[3] as well. Acharya and Vimi[2] mentioned that the curvilinear relationship indicates that translucency length does not have a tendency to decrease *per se* but slows down after 60 years, reaffirming that it plateaus in old age.

Conclusion

A simple and relatively inexpensive method for estimating age by measuring RDT has been described using conventional and digital aids. When tooth is the only clinching evidence available, even with a destroyed crown and an intact root, age can be determined reliably using the level of root dentinal transparency. In this study, age has been estimated with an accuracy of ± 5 years (61.4%) and ±10 years (12.9%). Further age determination obtained using regression coefficients of Bang and Ramm and the present study had 71.4% level of agreement. However, a longitudinal study on a larger sample size needs to be done.

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Conflicts of interest
There are no conflicts of interest.

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