Age estimation by dentin translucency measurement using digital method: An institutional study

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Abstract

Aims: The aims of the present study were to measure translucency on sectioned teeth using available computer hardware and software, to correlate dimensions of root dentin translucency with age, and to assess whether translucency is reliable for age estimation. **Materials and Methods:** A pilot study was done on 62 freshly extracted single-rooted permanent teeth from 62 different individuals (35 males and 27 females) and their 250 µm thick sections were prepared by micromotor, carborundum disks, and Arkansas stone. Each tooth section was scanned and the images were opened in the Adobe Photoshop software. Measurement of root dentin translucency (TD length) was done on the scanned image by placing two guides (A and B) along the x-axis of ABFO NO. 2 scale. Unpaired *t*-test, regression analysis, and Pearson correlation coefficient were used as statistical tools. **Results:** A linear relationship was observed between TD length and age in the regression analysis. The Pearson correlation analysis showed that there was positive correlation ($r = 0.52$, $P = 0.0001$) between TD length and age. However, no significant ($P > 0.05$) difference was observed in the TD length between male (8.44 ± 2.92 mm) and female (7.80 ± 2.79 mm) samples. **Conclusion:** Translucency of the root dentin increases with age and it can be used as a reliable parameter for the age estimation. The method used here to digitally select and measure translucent root dentin is more refined, better correlated to age, and produce superior age estimation.

Key words: Age estimation, computer software, dentin translucency, forensic odontology, Gustafson's criteria

Introduction

Estimation of a human corpse's age forms a pertinent part of forensics during the identification process of a cadaver that cannot be identified otherwise due to denaturation of the individual characteristics that would lead to an optical recognition.[1] Age estimation is of broader importance in forensic science not only for the identification purposes of the deceased victims but also in connection with crimes and accidents.[2] In a developing country like India, a large number of people are illiterate and have

no knowledge or records of their date of birth which is required by law enforcing agencies in matters such as criminal responsibilities, identification, judicial punishment, consent, rape, criminal abortion, employment, attainment of majority, kidnapping, and prostitution.[3]

Teeth usually survive postmortem destruction and are considered to be better suited for estimating age.[4] They often survive long periods of immersion under water, burial under oil, fire, exposure to biological agents in the natural environment. Thus, the importance of dental identification is increasing year by year.[5]

Scientific methods to evaluate dental age changes have developed over the last century, with Gustafson's morpho-histological approach, occupying a prominent position.[6] Other methods include analyzing tooth development and eruption, studying tooth degradation, and measuring biochemical and trace element changes in dental structures.[1] Studies on Gustafson's 6 variables found that dentin translucency was best suited for age estimation when used alone.[7]

Dentin translucency in root portion is one of the major changes seen with increasing age. Root translucency develops as the dentinal tubules within a tooth root begin to mineralize from the root apex toward the crown.[8] Miles believed that measuring the regressive changes was a better approach for age assessment than visually grading them and attempted age estimation from measuring translucency.[9]

Conventionally, translucency has been quantified with the help of Vernier calipers.[10,11] However, attempts to quantify translucency using digital aids have been proposed over the last two decades[12,13] with one group of researchers concluding that computer-based translucency measurements contributed best to age estimation.[14] The purpose of this study was to predict and correlate the chronological age by measuring the dentin translucency on sectioned teeth using standard computer hardware and commercially available computer software.

Materials and Methods

The present study is a pilot study and it was carried out at Department of Oral Pathology and Microbiology, King George's Medical University, Lucknow, India, after the approval from the Ethical Committee of the Institute.

The sample for the study comprised 62 freshly extracted permanent single-rooted teeth that belonged to 35 males and 27 females. The age of males ranged from 21 to 65 years while that of females from 20 to 62 years. The samples were obtained from the patients reporting at the Department of Oral and Maxillofacial Surgery, King George's Medical University, Lucknow. Teeth extracted for obvious clinical reasons such as periodontal problems, orthodontic purposes, and prosthodontic purposes were included in the study. Teeth with root caries, abrasion, erosion, and external resorption were excluded from the study.

Once teeth were extracted, they were thoroughly cleaned and soft tissue remnants were removed from the root surface with a scalpel. Teeth were then sectioned longitudinally to 250 μm thickness in the buccolingual plane as close as possible to the central axis of the tooth using micromotor, carborundum disks, and Arkansas stone. The thickness of sections was measured by using digital screw gauge.

Digital translucency measurement

Assessment of dentin translucency was done with a newer digital translucency measurement method suggested by Acharya.[4] This method included conventional computer, CRT monitor, and flatbed scanner (HP Scanjet G3010, Hewlett-Packard Co., Palo Alto, CA, USA). Each tooth section was placed next to an ABFO No. 2 scale (Lightning Powder Co., Inc. Jacksonville, FL, USA) on the scanner platen and scanned at a resolution of 600 dpi. The long axis of the section was aligned parallel to the y-axis of the scale [Figure 1]. The scanner lid was kept open while scanning and ambient light conditions kept to a minimum to get the translucency in the desired area.

For measuring translucency area, the scanned images were opened in Adobe Photoshop 7.0.1 image editing software program (Adobe Systems Inc., Mountain View, CA, USA) installed in a Lenovo ThinkCentre desktop computer (Intel Core™ i3-2100 Processor; 3.10-GHz CPU, 4.00 GB RAM) (Lenovo Group Ltd., Hong Kong, China). The length of translucency in dentin of root (TD length) was selected using the following steps as described by Johansen and Bowers for digital analysis of bitemark evidence.[15]
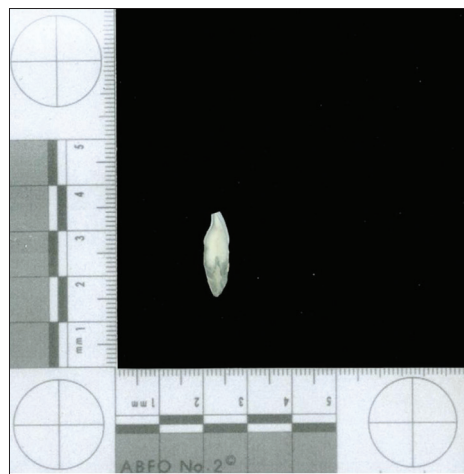

Figure 1: Scanning of tooth section with long axis aligned parallel to the y-axis of the ABFO NO. 2 scale

The "Zoom Tool" in the toolbox of Photoshop was selected to magnify the scanned image to a zoom setting of 66.7%. Two "guides" (Guide A and Guide B) were placed on the image to mark the apical and coronal extent of translucency [Figure 2]. These guides can be placed by inserting Photoshop's in-built "rulers" along the edges of the image. When the rulers were activated, guides were placed by clicking the cursor within the x-axis (horizontal part) of the ruler and dragging onto the image. To move a guide, the "Move Tool" was used.

Once the respective guide was placed at the apical and coronal extent of root dentin translucency, the distance between them was obtained using the "Measure Tool" in the toolbox. Using this tool, a line was drawn between the guides and the distance (TD length) was displayed in the Options Bar [Figure 2]. The measuring line drawn can be kept vertical by holding down the Shift key. The units were ensured to be in millimeter by comparing with the reference ABFO No. 2 scale. The measurements obtained using the Measure Tool are sensitive to 0.1 mm.

Statistical analysis

The measurements were tabulated and subjected to statistical analysis. Unpaired *t*-test was used to compare TD length between males and females. In addition, the regression analysis was carried out for the prediction of age on the basis of TD length. The Pearson correlation coefficient was also calculated to see the correlation between predicted age and TD length. All the analyses were carried out using Statistical Package for Social Sciences 16.0 version (SPSS Inc., Chicago, IL, USA).

Results

Out of the 62 tooth samples, 56.5% were male while 43.5% were female. The age of males ranged between 21 and 65 years with the mean of 40.49 ± 5.85 years. While

the age of females ranged between 20 and 62 years with the mean of 39.55 ± 4.25 years [Table 1]. There was no significant difference ($P > 0.05$) in the TD length between male (8.44 ± 2.92) and female (7.80 ± 2.79) patients [Table 2].

However, there was found to be a linear relationship between TD length and age in the regression analysis [Figure 3]. Regression analysis showed following results:
- Y-intercept: 25.28; it is the lowest value of age at which translucency of the dentin was zero
- Coefficient of slope: 1.81 is a measure of change in translucency when age changes by unit (that is, when age changes by a year; there is a 0.018 mm change in the translucency length).

Based on the available data, the regression equation derived was

Predicted age = 25.28 + 1.81 × TD length

The Pearson correlation analysis showed that there was a positive correlation between age and TD length with a statistically significant correlation coefficient ($r = 0.52$, $P = 0.0001$).

Table 1: Demographic details of the patients

Parameter	*n* (%)	Age (years)	
		Minimum-maximum	Mean±SD
Male	35 (56.5)	21-65	40.49±5.85
Female	27 (43.5)	20-62	39.55±4.25
Combined	62 (100)	20-65	40.02±9.97

Table 2: Comparison of translucent dentin length (mm) according to gender

Gender	TD length (mm), mean±SD	*P**
Male	8.44±2.92	0.38
Female	7.80±2.79	

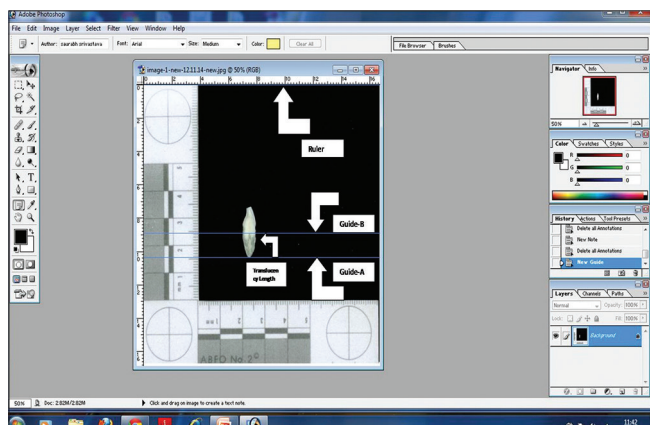*Unpaired *t*-test. TD: Translucent dentin, SD: Standard deviation

Figure 2: Measurement of root dentin translucency (TD length) on the scanned image opened in Adobe Photoshop software, by placing two guides (A and B) along the x-axis of ABFO NO. 2 scale
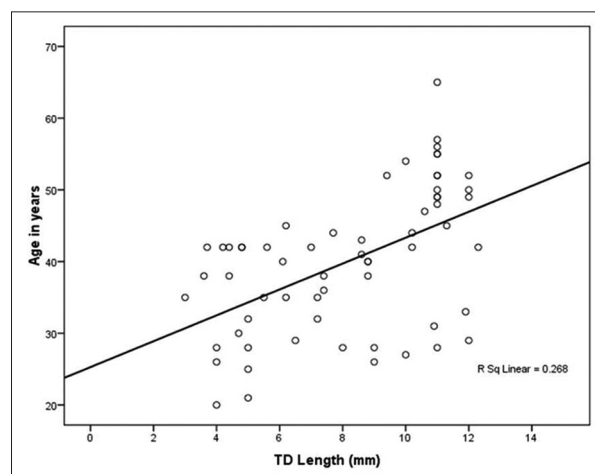

Figure 3: Scatter plot showing correlation of TD length to age and linear regression line

- Correlation coefficient (r): 0.52 denotes the correlation between age and length of translucency
- Coefficient of determination ($r^2 = 0.268$): 27% is a proportion of the variability explained by the regression equation.

Discussion

Many approaches have been suggested for age estimation by means of direct and indirect observation of teeth with the use of microscope or even the science of histology.[16] One of the most simple and reliable of Gustafson's criteria for age estimation is by the measurement of root dentin translucency.[6] It starts in the apical part of root and increases with age in the coronal direction.[10] This particular change is least affected by environmental factors and the pathological process.[17,18] It also shows symmetrical distribution on both sides of jaws.[19]

Tomes was the first investigator to describe the translucent dentin. He described that translucency is the result of the consolidation of the dentinal tubules and he noticed that if the air in the dentinal tubules of a tooth is replaced by water, the tooth becomes more translucent. He held the opinion that various types of translucency arose because of an equalization of the normally different indices of refraction of the tubules and of the calcified dentin matrix.[1] The increase in translucency is generally considered as a physiological change with aging process as proved by Azaz *et al*.[18]

According to Miles and Bang and Ramm, an advantage of translucency measurements is that a relatively inexperienced examiner can use it to estimate age.[9,10] Indeed, translucency can be assessed macroscopically on intact teeth although tooth sections provide better detail.[10] Sectioned teeth were used in the present study for this particular reason.

The 250-μm-thick tooth sections ensured the best possible visualization of translucency. Hence, large-scale interest in assessing this parameter resulted in several published papers that evaluated both length and area measurements.[20-23]

If the parameter of translucent length and area of tooth are compared, the length shows more reliability as compared with translucent area of the tooth.[23] Thomas *et al*. also suggested that dentin translucency using linear measurement is more reliable than area plotting.[22]

Dentin translucency has been quantified with the help of Vernier calipers in the conventional techniques.[10,11] Recently, however, attempts to quantify translucency using digital aids have been made.[12,13] However, these computer-based methods require the use of custom-built software programs and required capturing tooth images on a video camera, converting the analog signal to a digital signal, and subsequent image processing. Therefore, a

newer simpler digital translucency measurement method suggested by Acharya to digitally select and measure translucent root dentin length was used here.[4]

In the present study, the tooth samples from the patients of a wide age range between 20 and 65 years had been obtained with the mean age of 40.02 (±9.97) years. Out of 62 tooth samples, 56.5% were male while 43.5% were female.

Unpaired *t*-test used to compare TD length between males and females showed that there was no significant difference ($P > 0.05$) in the TD length between male (8.44 ± 2.92) and female (7.80 ± 2.79) patients. The available data suggest that gender factor has no role in the development of dentin translucency.

However, Pearson correlation analysis showed that there was a positive correlation between the translucencies (TD length) with advancement of age, which is supported by the studies of Solheim, Whittaker and Bakri, Johnson, and Singhal *et al*.[19,20,23,24]

It is interesting to note that there is a gradual and definitive increase in the ratio of this translucency length with that of increase in age. The correlation coefficient obtained in the study was 0.52 which is statistically significant ($P < 0.001$) and was closer to that obtained in previous studies conducted by Miles, Azaz *et al*., and Johnson.[9,18,24]

A linear relationship between TD length and age in the regression analysis has been observed. It was found that with increase in the age by 1 year, the length of translucency in the root also increases by 0.018 mm as depicted by the coefficient of slope.

However, in some of the teeth in this study, younger individuals have shown more translucent zone, which resulted in overestimation of age. This flaw may be attributed to the presence of periodontal infections and diseases of the pulp. The chronic periodontal infection may stimulate far more mineralization resulting in the increased translucent zone in the root part of dentin.[23]

Similarly, there was a contradictory factor that a lesser amount of translucency was encountered in some old individuals in our study that resulted in underestimation of age. This is probably due to slowing down of the process of sclerotic dentin formation in some of the individuals for various reasons. Further, beyond the age group, it is also possible that increase in the translucency does not take place because it could have attained the highest level by blocking all the dentinal tubules in that area and thus giving a static value of translucency after a particular age.[23]

The digital approach used in the present study can be categorized as a semi-automatic analysis since the limits

of translucency are designated manually. The superiority of this method over the traditional methods is that the images can be stored and conveniently retrieved for future use, irrespective of the condition of the actual tooth section. An additional advantage of the present method is that the software program used is commercially available and a widely used image editing digital aid. Furthermore, digitizing tooth sections are straightforward with current computer hardware and software.[4]

Conclusion

It can be concluded that translucency in the apical part of the tooth can be used for estimating the age of an individual. A method to digitally select and measure translucent root dentin length was used here, and it produced a positive correlation between age and translucency of dentin. The available data also showed that there was no significant difference in the translucency length between male and female patients. Due to its relative simplicity, we recommend the use of this method in routine forensic dental age estimation.

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Conflicts of interest
There are no conflicts of interest.

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