

Comparative study of age estimation using dentinal translucency by digital and conventional methods

Sushma Bommannavar,
Meena Kulkarni
*Department of Oral Pathology
and Microbiology, Dr. D. Y. Patil
Dental College and Hospital,
Pimpri, Pune, Maharashtra, India*

Address for correspondence:
*Dr. Sushma Bommannavar,
Department of Oral Pathology
and Microbiology, Dr. D. Y. Patil
Dental College and Hospital,
Pimpri, Pune, Maharashtra, India.
E-mail: drsushopath@gmail.com*

Abstract


Introduction: Estimating age using the dentition plays a significant role in identification of the individual in forensic cases. Teeth are one of the most durable and strongest structures in the human body. The morphology and arrangement of teeth vary from person-to-person and is unique to an individual as are the fingerprints. Therefore, the use of dentition is the method of choice in the identification of the unknown. Root dentin translucency is considered to be one of the best parameters for dental age estimation. Traditionally, root dentin translucency was measured using calipers. Recently, the use of custom built software programs have been proposed for the same. **Objectives:** The present study describes a method to measure root dentin translucency on sectioned teeth using a custom built software program Adobe Photoshop 7.0 version (Adobe system Inc, Mountain View California). **Materials and Methods:** A total of 50 single rooted teeth were sectioned longitudinally to derive a 0.25 mm uniform thickness and the root dentin translucency was measured using digital and caliper methods and compared. The Gustafson's morphohistologic approach is used in this study. **Results:** Correlation coefficients of translucency measurements to age were statistically significant for both the methods ($P < 0.125$) and linear regression equations derived from both methods revealed better ability of the digital method to assess age. **Conclusion:** The custom built software program used in the present study is commercially available and widely used image editing software. Furthermore, this method is easy to use and less time consuming. The measurements obtained using this method are more precise and thus help in more accurate age estimation. Considering these benefits, the present study recommends the use of digital method to assess translucency for age estimation.

Key words: Age estimation, caliper method, dental identification, dentin translucency, digital method, forensic dentistry

Introduction

Age estimation using the dentition enacts an important step in human identification. Proper identification in forensic odontology is required for ethical, humanitarian and official records, in particular, the legal and criminal investigations. It enables us to construct a mortality profile of the deceased. Several points that are usually noted for the purpose of identification include age, sex, race and stature. In cases where the human remains are visible, the family and friends of the deceased can attest to their identity, whereas in

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enigmatic situations such as mass disasters and decomposed postmortem remains, where viewing is not possible, other means of identification are required to be used. In such circumstances, the dental hard tissues gain importance in identification owing to the fact that the two hard structures of teeth, enamel and dentin bestow the properties of hardness and resilience respectively.^[1,2] Because both these tissues are mineralized, they give teeth a unique property of permanency making them resistant to environmental insults and postmortem decomposition and hence can be retained without distortion. Thus, human dentition provides an important clue in tracing the unknown and corroborate in the identification of individuals in forensic odontology.

The estimation of the chronological age using dentition has been performed by various methods in forensic sciences. Among these, the most commonly used the scientific method of identification is using the dentition. Dental age is one of the few measures of physiological development that are applicable from infancy to adolescents. Teeth undergo structural changes after maturity, thus making age estimation possible in adults.^[3] In the dental method of identification, the Gustafson's morphohistologic approach is most widely used method and includes the following six parameters, i.e. attrition, gingival recession, thickness of secondary dentin, cementum apposition, root resorption and root dentin translucency. In all these, root dentin translucency is considered to be the best parameter for dental age estimation.^[4] Transparency begins in the apical part of the root and increases in the coronal direction.^[5] It is least afflicted by environmental and pathological processes,^[4,6] demonstrating symmetrical distribution on both sides of the jaws.^[7]

Traditionally, translucency was usually measured with the help of calipers. However, several attempts were made to measure translucency using computer-based customized software over the last few years. These methods included capturing the tooth images on the video camera and subsequent image processing was carried out using the customized software programs. With the advance in technology, digital evaluation of translucency can be made easily today. The present study was performed to describe a new approach of measuring translucency on digital images of thin tooth sections made manually using Arkansas stone and also to compare this method with the traditional caliper method so as to ascertain the methods effectiveness in forensic age estimation.

Materials and Methods

A total of 50 permanent teeth from many individuals in the age group of 21-80 years were collected from the Department of Oral and Maxillofacial Surgery, Dr. D. Y. Patil Dental College and Hospital, Pune; Y.C.M. Hospital, Pune and from private clinics in and around Pune. Criteria for the selection included those individuals who had to undergo extraction for orthodontic purpose, mobility and fabrication of dentures.

The tooth samples collected were stored in 10% formalin in camera roll bottles. Name, age, sex and address of the patient were recorded by the teaching staff and all the corresponding teeth were given code numbers, which were displayed on the bottles. This was carried out for the purpose of convenience so that during the time of sectioning the samples, the actual age of the subject remained unknown. The teeth were cleaned for any soft-tissue fragments, calculus, stains, etc., The teeth were then sectioned longitudinally to 0.25 mm thickness in the buccolingual plane using Arkansas stone. The sectioned samples were then cleaned under running water and the thickness was measured using the digital caliper.

Conventional caliper method

Sampled sections of 0.25 mm thickness were taken from the bottles and dried on the blotting paper. The section was then placed on an X-ray viewer. The digital caliper was placed adjacent to the tooth section on the X-ray viewer. The caliper beaks of the digital caliper were adjusted and extended from the apical limit of the root translucency to the coronal limit of root translucency as shown in Figure 1. The values obtained were recorded and the section was again placed back into its respective bottle.

Digital method

The same section was placed on a HP Scanjet G3010 flatbed scanner (Hewlett Packard Co., Palo Alto, CA, USA). Two scales were placed on the scanner, one in X-axis (horizontally) and other in the Y-axis (vertically). The scanner lid was kept open while scanning; keeping the lid closed obstructs the passage of light and renders the entire tooth section opaque. Once 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 is used and simultaneously, the Ctrl key is held down and the guide moved to the desired location. In this way, one guideline was placed on the apical limit and one on the coronal limit of root translucency. Once the

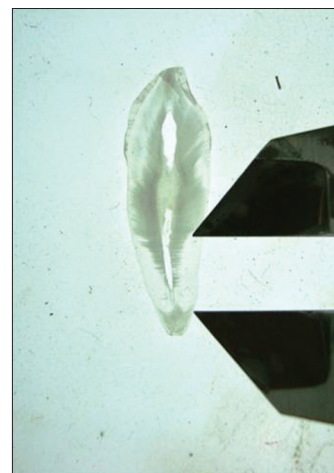


Figure 1: Scanned image of the tooth section using conventional caliper method

respective guidelines have been placed at the apical and coronal extent of root dentin translucency, the distance between them is measured using the Measure Tool on the Tool box. On the right side of the Adobe Photoshop, there are different tools seen such as Select tool, Magnifier tool and Eyedropper tool. From all these, the Eyedropper tool is selected and right click on this tool gives the following options like Color sampler tool and Measure tool. Select the Measure tool and using this tool, a vertical line is drawn by holding down the Shift key between the guides. Once this line is drawn, the distance (D1) gets displayed in the Options Bar as shown in Figure 2. If the Options Bar is not displayed, it can be activated by choosing Window Options. All the measurements were recorded in mm and the D1 value obtained was recorded. The results were subjected to regression analysis using the statistical package for Social Sciences Software (SPSS). SPSS, Inc, Chicago, IL.

Statistical analysis

The measurements obtained from both the methods were divided into 2 groups. The 1st group comprised of sections of teeth in which the age was estimated using the caliper method and 2nd group comprised of sections of teeth in which the age was estimated using the digital method. Statistical analysis was performed using the paired *t*-test on both groups to evaluate the potential difference between both methods. Furthermore, the translucency measurements obtained from both methods were correlated to known age using linear regression analysis. The Pearson’s correlation coefficient with linear regression formula was derived for each group.

For the group 1, the regression formula was:
Age: 25.874 + (5.597 × translucency length).

For group 2, the regression formula was:
Age: 22.809 + (5.364 × translucency length).

Results

Results showed that in both methods the mean of digital method was 5.2 mm as against 5.5 mm for the conventional method. The paired *t*-test also revealed no statistically significant differences between both the methods (*P* < 0.125). Pearson’s correlation and linear regression equations are shown in Table 1. Applications of linear regression equations for digital and conventional method are shown in Tables 2 and 3.

Table 1: Pearson’s correlation coefficients (r) and regression equations derived from conventional and digital translucency measurements

Method	n	r	Regression formula
Caliper method	50	00.713	Age: 25.874 + (5.597×TL)
Digital method	50	00.756	Age: 22.809 + (5.346×TL)

TL= Translucency

Table 2: Derivation of the regression equation for age estimation for group 1

Group	Unstandardized coefficients		Standardized coefficients	t	Significant
	B	Standard error	Beta		
Group 1	5.597	0.794	0.713	7.051	0.000
Constant	25.874	4.169		6.206	0.000

Table 3: Derivation of the regression equation for age estimation for group 2

Group	Unstandardized coefficients		Standardized coefficients	t	Significant
	B	Standard error	Beta		
Group 2	5.364	0.671	0.756	7.999	0.000
Constant	22.809	4.063		5.614	0.000

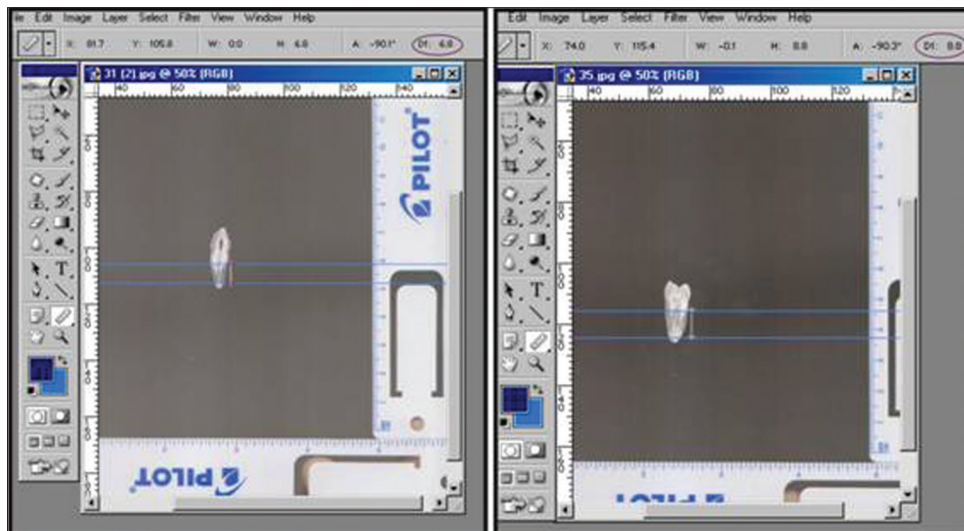


Figure 2: Scanned image of the tooth section using digital method Adobe Photoshop 7.0 version. Note the D1 value encircled at the top left side of the image on the option bar

The correlation coefficient for translucency measurements were marginally higher for the digital method ($r = 0.74$). Furthermore, the linear regression formula derived revealed better ability of the digital method to assess age. This indicates that the digital method could estimate age to within ± 5 years in about 70% of cases and can be used as a substitute to caliper method and the digital method measurements can better correlate with the known age of the individual. Figure 3 shows diagrammatically the relationship between translucency measurements between digital and conventional methods.

Discussion

Assessment of age from the dentition is of great interest for the forensic Odontologist in his work on identification of the unknown. The Gustafson technique is the most popular age estimation method that uses six variables, among which root dentin translucency is considered the best parameter for age estimation.

Root dentin translucency starts always near the apex and spreads towards the cemento-enamel junction. This appears dark in reflected light and transparent in transmitted light.^[8] This can be visualized in ground sections of the teeth. Root dentin transparency develops due to progressive sclerosing of the tubules, first at the root apex, then advancing coronally. De Jonge reported that the average width of dentinal tubules is about 3.2μ in young individuals, narrowing to about 1.5μ at 50 years and down to 1.2μ at 70 years of age. According to Bang and Ramm and Miles,^[5,9] an advantage of translucency measurements is that it is simple and age can be estimated even by an inexperienced examiner. Translucency can be assessed macroscopically on intact teeth, but tooth sections provided better results and can be scanned easily. This was the reason why sectioned teeth were used in this study.

In the past, root dentin translucency was measured using a digital caliper on the teeth sectioned using a hard tissue

microtome. The major drawback faced in using this method was that the sectioned teeth were subjected to caliper beaks, which could not be properly stabilized and thus increasing the risk of damage or fracture of these sections by the pointed beaks. Also, the magnification aid used was the magnifying glass, which could not enhance the exact clarity between the translucent and the opaque zone. Hence, the present study was conducted to measure root dentin translucency on teeth sectioned manually using Arkansas stone by a computer-based method applying Adobe Photoshop software 7.0 version. Adobe Systems Inc, Mountain View CA.

The advantage of the digital method is that the translucency measurements obtained were magnified at $\times 3$ magnifications using the Zoom Tool, which allowed better visualization of the junction between the transparent and opaque zone. This could not be accomplished by the caliper method; hence, one can conclude that some amount of magnification is necessary for accurate age estimation. Also, the absence of statistically significant differences between the digital and the conventional caliper method proved that the digital method can substitute the conventional method. Furthermore, accuracy of age estimation using the present digital method is much higher to that of a caliper method.

Previous studies by Drusini *et al.*^[10] attempted to estimate the age of an individual using root dentin translucency on intact teeth by an image analysis system Integral Burst Alert System 2000 and caliper method. This study gave predictive value of 45-48%. Also, this method was expensive, time consuming and required graphical illustrations of the results and immediate storage of the statistical information. Indeed, Lopez Nicolas *et al.*^[11] recommended finding alternative method when he evaluated the image analysis systems used in earlier studies for digital quantification of translucency. Valenzuela *et al.*^[12] also concluded that computer-based translucency measurements contributed best to estimate the age. Hence, there arose a need for the alternative approach and the best one was using the Adobe Photoshop software.

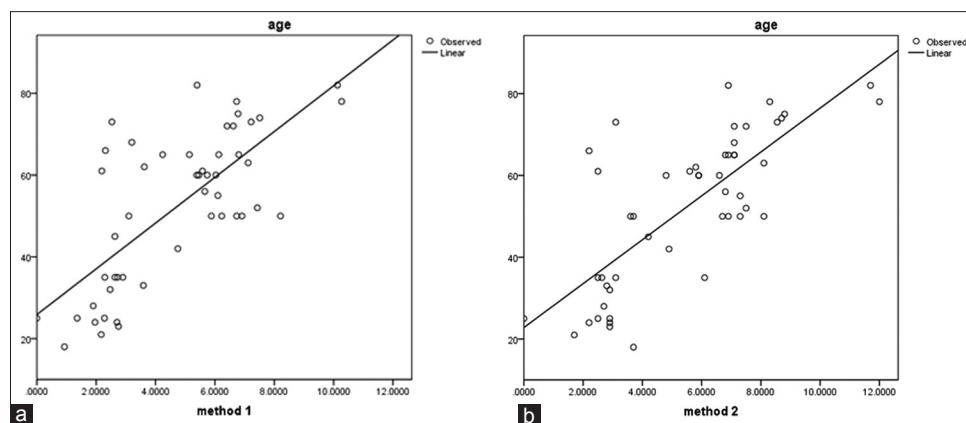


Figure 3: (a and b) Graphical presentation showing correlation of root dentin translucency to age and regression line for conventional method and digital method

Acharya^[13] attempted a similar study wherein the tooth were sectioned using a hard tissue microtome. In the present study, the teeth were sectioned manually with Arkansas stone. There was no much difference in age seen when the tooth were sectioned manually.

In the present study, age estimation using linear regression equations showed better efficiency of the digital method to estimate age when compared with the caliper method. The age estimated was within ± 5 years in 70% of the cases, where only 24% of cases were estimated to within ± 5 years with the caliper method. Also, the Pearson's correlation and linear regression formulae revealed very minute differences between both the methods. The software required to analyze dentin translucency is readily available and tooth sections can be digitized easily. Also, the images can be stored for future use, irrespective of the condition of the actual tooth section. Hence, the author recommends the use of digital method to estimate the age.

In conclusion, the present study was conducted to estimate the age of an individual on sectioned teeth made manually with Arkansas stone using the conventional caliper method and the digital method by computer-based software with the help of Adobe Photoshop version 7.0 and to compare both these methods with the known age of the individual. The benefit of this study is that the digital method used is commercially available and widely used image editing software. Also, the sections were manually carried out with Arkansas stone, which is routinely available rather than hard tissue microtome. This method is easy to use and less time consuming. The measurements obtained using this method are more precise and thus help in more accurate age estimation.

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