Conventional versus digital approach for measuring dentin translucency in forensic age estimation

Varun Chopra,
Gopal Thodasam[1],
Zeeshan Heera Ahmad[2],
Simranjit Singh[3],
Indresh Rajawat[4],
Sonal Gupta[5]

Department of Oral and Maxillofacial Pathology, Mauras College of Dentistry and Hospital and ORI, Arsenal, Republic of Mauritius, [1]Department of Conservative Dentistry and Endodontics, Sri Balaji Dental College and Hospital, Venkapally, Moinabad, Ranga Reddy, Telangana, [2]Department of Conservative Denistry and Endodontics, Private Practitioner, Bangalore, Karnataka, [3]Department of Oral and Maxillofacial Pathology, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, [4]Department of Prosthodontics and Crown and Bridge, Institute of Dental Education and Advance Studies, Gwalior, Madhya Pradesh, [5]Department of Oral and Maxillofacial Pathology, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India

Address for correspondence:
Dr. Simranjit Singh, Department of Oral and Maxillofacial Pathology, Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry, India. E-mail: drsmrnjt4@gmail.com

Abstract

Background: Root dentine translucency remains the method of choice providing the most accurate results for age estimation. Conventionally, translucency is measured using calipers. In recent times, computer-based methods are proposed, which require the use of custom-built software programs. **Aims and Objectives:** The aim was to use a digital method to measure dentinal translucency on sectioned teeth and to compare digital measurements to conventionally obtained translucency measurements. **Materials and Methods:** A total of 200 extracted permanent teeth were collected and were sectioned to a thickness of 250 μm. Translucency measurements were obtained using the digital method and compared with those obtained using a caliper. **Results:** Correlation coefficients of translucency measurements to age were statistically significant for both methods ($P < 0.001$), although marginally higher correlation was observed for the conventional method ($r = 0.612$). Application of derived linear regression equations on an independent sample ($n = 25$) suggested that conventional approach is marginally better in estimating age to within 5 years of the actual age, both the methods are similar in assessing age within 5-10 years of the actual age, and digital approach is marginally better in estimating age beyond 10 years of actual age. **Conclusion:** The translucency measurements obtained by the two methods were identical, with no clear superiority of one method over the other.

Key words: Age assessment, computer software, dentinal translucency, forensic odontology, Gustafson's criteria

INTRODUCTION

Age estimation methods are commonly used in forensic investigations and anthropological studies.[1,2] Teeth usually survive postmortem destruction and are considered to be better suited for estimating age.[3,4] The methods of age estimation using teeth include analyzing tooth development and eruption, studying tooth degradation and measuring biochemical and trace element changes in dental structures.[2,5]

Many variables including dental histological techniques can contribute to age determination.[6] The choice to use teeth for age determination is well accepted due to their longevity ability of being resilient to change.[7,8] The physiological or biological aging is in many cases not related to calendar (chronological) aging. In this manner, a biological marker independent of any environmental alteration is necessary to provide information about the age of an individual.[1,6,7] Root dentine translucency is one such biomarker.[2,9,10]

Traditionally, translucency is measured using Vernier calipers.[4,10,11] Attempts to quantify translucency using digital aids are now available.[4,12,13] However, these computer-based methods require the use of custom-built software programs and capturing tooth images using a video camera, followed by extensive image processing.[4] This study hence was undertaken to use a simple digital method for quantifying dentinal translucency and to compare digital measurements to conventionally obtained

translucency measurements. We also compared the applicability of conventional and digital methods on an independent sample.

MATERIALS AND METHODS

Tooth sampling and sectioning

Two hundred extracted permanent teeth from 200 different individuals in the age group of 18-80 years (mean age, 47.66 years) were obtained from the Department of Oral and Maxillofacial Surgery of Mahatma Gandhi Postgraduate Institute of Dental Sciences, Puducherry. The 200 specimens consisted of 50 specimens from our previous study.[14] Single rooted permanent teeth extracted for valid clinical reasons such as orthodontic treatment, periodontal disease and caries were included in the study. Carious teeth were included in the sample provided the roots of the teeth were macroscopically unaffected. Multi-rooted teeth, grossly decayed teeth, impacted teeth, teeth with severe attrition, root caries and internal resorption were excluded from the study. The extracted teeth were cleaned and sectioned longitudinally to 250 µm in the buccolingual plane as close as possible to the central axis of the tooth using micro motor, diamond disks and carborundum stones.

Conventional translucency measurement

Conventional translucency measurements were performed by placing the tooth sections in front of a constant light source (Philips LED 12.5W A19, Koninklijke Philips N.V., Amsterdam, The Netherlands) and the maximum distance between the apical limit and the most coronal extent of translucency within the root was measured using a caliper. The measurements made were sensitive to 0.1 mm.

Digital translucency measurement

The method used in this study for measuring dentin translucency is adapted from previously different steps for digital analysis of bitemark evidence[15] and dentin translucency.[4] The computer hardware used in the method included a Dell 2.26 GHz CPU with 4 GB RAM and a 15.4 inch LCD monitor and a BenQ scanner 5000 (BenQ Corporation, Taiwan). Each tooth section was placed next to an American Board of Forensic Odontology (ABFO) no. 2 scale (Tritech Forensics, Phoenix, AZ, USA) on the scanner platen.

The long axis of the section was aligned parallel to the y-axis of the scale. Prior to scanning, the scanner setting was verified to be 100% of the original to ensure life-size scanned images. Subsequently, an image of 600 dpi resolution of the section with scale was obtained [Figure 1]. Scanned images were imported to Adobe Photoshop version 7.0 image-editing software (Adobe Systems Incorporated, San Jose, CA, USA) for viewing and translucency measurements. Translucent dentin appears as a dark region on the tooth section when compared with the other dental tissues [Figure 1]. For measuring translucency, Photoshop's in-built "rulers" were activated along the edges of the image (on the Menu Bar, choose View > Rulers, or Ctrl + R, or Command + R for Macintosh systems). The units were ensured to be in millimeters by comparing with the reference ABFO no. 2 scale. In the event units were not in millimeters, choose Edit > Preferences > Units and Rulers and select "mm" under units and click OK. Once the rulers were activated, guides were placed corresponding to the apical and coronal extent of root dentin translucency by clicking the cursor within the x-axis (horizontal part) of the ruler and dragging onto the image [Figure 2]. To move a guide to the desired location, the move tool was used; alternatively, the Ctrl key was held down (command key for Macintosh systems). Once the respective guides were placed at the apical and coronal extents of root dentin translucency, the distance between them was obtained using the measure tool on the toolbox. Using this tool, a line was drawn between the guides; the distance (D1) was
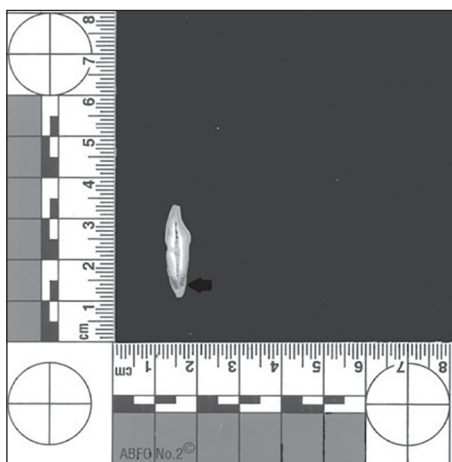

Figure 1: Scanned image of a tooth section with an American Board of Forensic Odontology no. 2 scale. Translucent dentin (arrow) appears as a dark area on the section
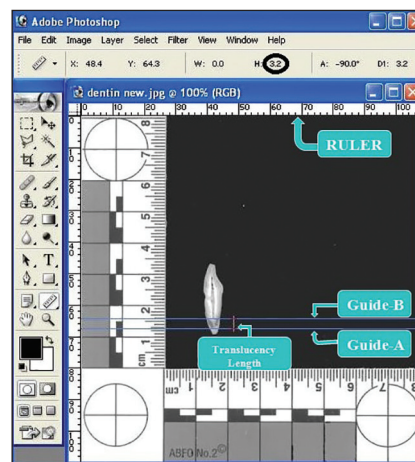

Figure 2: Measurement of dentin translucency using Adobe Photoshop. Guides A and B correspond to apical and coronal limits of translucent dentin, respectively

displayed in the options bar [Figure 2]. If the options bar is not displayed, it can be activated by choosing Window > Options. Measurements obtained using the measure tool were sensitive to 0.1 mm. The measuring line drawn was kept vertical by holding down the Shift key.

Statistical analysis

Translucency measurements obtained from both methods were correlated to known age using linear regression analysis. Pearson's correlation coefficients obtained for both methods were documented and the regression equations derived was used to calculate age on a control sample of 25 sections (obtained from 25 subjects whose ages ranged between 20 and 79 years). These sections were not used in deriving the regression formulas. The difference between estimated and known age for both methods was compared.

RESULTS

Pearson's correlation coefficients (*r*) and linear regression equations are shown in Table 1. The correlation coefficients were statistically significant for both conventional and digital methods (*P* < 0.001). The correlation coefficient was slightly higher for conventional measurements (*r* = 0.612) when compared with digital measurements (*r* = 0.610).

Application of linear regression equations on the control sample (*n* = 25), which included the sections that were not used in deriving the regression formulas, showed that conventional method could estimate age to within 5 years of known age in eight of 25 cases (32%) whereas digital method could do the same in 6 of 25 cases (24%), but both methods could estimate age to within 10 years of known age in 6 of 25 cases [Table 2]. However as we moved further down, the digital method proved to be better in

estimating age beyond 10 years of known age (52%) as against the conventional method (44%). Figures 3 and 4 depict scatter plots showing the correlation of known age to the estimated age for the conventional and digital methods. There was no appreciable difference between the scatter plots of the two methods.

DISCUSSION

Dental translucency measurements to determine age as considerably evolved in forensic examinations.[9] Translucency of the root apex seems to be the most reliable in predicting the actual age. However, there is a gradual extension of the processes responsible for this translucency further and further in the direction of the crown as age advances, until, in due course, the whole of the root may be affected.[2,16-18] Bang and Ramm[10] were the first to use dentin translucency alone for estimating age and reported significant increase in root translucency with age. The underlying process behind translucency of dentin is a result

Table 1: Correlation coefficient (*r*) and regression equations derived from the conventional and digital translucency measurements

Methods	n	r	Regression equation
Conventional	200	0.612	Age=29.720+(4.102×translucency length)
Digital	200	0.610	Age=29.823+(3.930×translucency length)

Table 2: Accuracy of age estimation of conventional and digital methods on a control sample

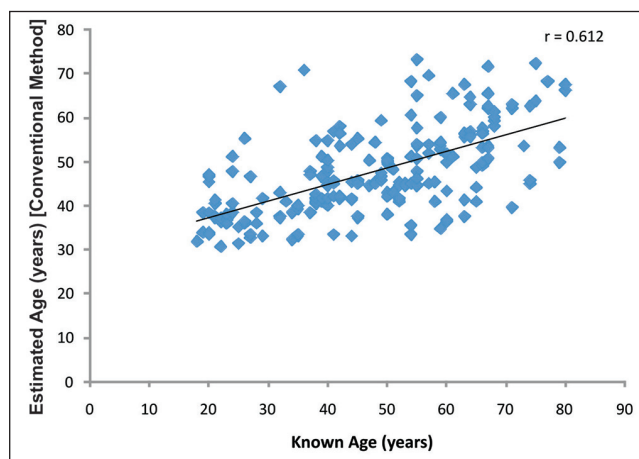| Methods	Control sample	Errors of estimated age		
		<5 years %	5-10 years %	>10 years %
Conventional	25	32 (8/25)	24 (6/25)	44 (11/25)
Digital	25	24 (6/25)	24 (6/25)	52 (13/25)

Figure 3: Scatter plot showing correlation of known age to the estimated age for the conventional method
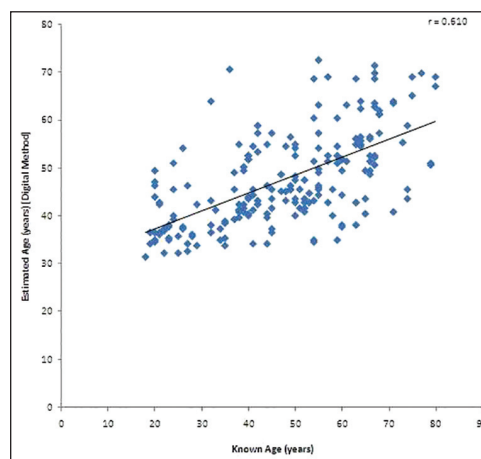

Figure 4: Scatter plot showing correlation of known age to the estimated age for the digital method

of fatty degeneration,[19] physiological hardening during the life-time of the tooth due to increased deposition of the calcific matter,[20] consolidation of the dentinal tubules, equalization of the normally different indices of refraction of the tubules and of the calcified dentine matrix,[2,21] decreased diameter of dentinal tubules caused by increased intratubular calcification and difference in refractive indices between intratubular organic and extratubular inorganic material is equalized, resulting in increased translucency of the affected dentin.[3]

Dentine translucency as a parameter to assess age has distinct advantages over the other methods.[10] It is one of the simplest methods to assess and estimate age.[4,10,22] Moreover, it is least affected by environmental factors and the pathological process.[9,23-25] It also shows symmetrical distribution on both sides of the jaws.[23,26] Furthermore, translucency can be assessed macroscopically on intact teeth, although tooth sections provide better detail.[4,10] Hence sectioned teeth were used in this study.

There are compelling reasons for using the digital method over the conventional method for obtaining translucency measurements. Digital method allows better visualization of the junction between translucent and nontranslucent zones, giving scope for "fine-tuning" the measurements.[4,14] A magnifier can also be used in the conventional method; however, irrespective of magnification, an impediment to caliper-based measurements is that the caliper beaks cannot always be stabilized on thin tooth sections as there is risk of damaging it. Hence, calipers are probably better suited for measuring translucency on intact teeth. On the other hand, the "touch-free" or "noninvasive" digital evaluation prevents potential damage to thin tooth sections.[4,14] The scanned images can be easily stored and conveniently retrieved for future use, irrespective of the condition of the actual tooth section.

Minimal variation was observed for the Pearson's correlation coefficients between the two methods [Table 1]. However, consistent with previous reports[12,27] conventional measurements were better correlated to age. The results of the present study substantiate and support the results of our previous study, which were performed on a smaller sample size.[14] In the present study, age calculation using linear regression equations on the control sample (*n* = 25) showed conventional method to be better in estimating age to within 5 years of known age as compared to the digital method, which is similar to the results obtained in our previous study. However these results are in contrast to other studies,[4] reporting superiority of digital based methods. Interestingly, both methods showed similar ability to estimate age within 10 years of known age, which is in contrast to our previous study in which digital approach

proved to be better in estimating age within 10 years of known age. Nevertheless, the digital method proved to be better in estimating age beyond 10 years of known age as against the conventional method, consistent with our previous study.

We concluded that the results obtained by both the methods that is, conventional and digital, are similar and consistent with findings of our previous study using smaller sample size.

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