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Comparative Study of Age Estimation from Dentin Translucency and Coronal Pulp Cavity Index Using Digital Method

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Abstract

Aim: The aim of the study was to evaluate and compare the two parameters of age estimation i.e., radiovisiographic method for measuring coronal pulp cavity index and digital method for measuring dentin translucency.

Study Design: Prospective study.

Materials and Methods: The present study was carried out in 100 patients in the age ranges of 18-25, 26-35, 36-45, 46-55, and 56 and above visiting clinical departments of the institute for various reasons like Orthodontics, Periodontics and Prosthodontics. The radiovisiographic examination of the tooth to be extracted was done. The tooth was then extracted under local anesthesia following this, the extracted teeth were cleaned of any debris with the help of hydrogen peroxide or under running water and then sectioned using micro motor hand piece, diamond disks and Arkansas stone. The teeth were sectioned longitudinally to 250 µm as close as possible to the central axis of the tooth. For measuring digital translucency each tooth section was placed on the scanner platen. Scanned images were imported to Adobe Photoshop software for viewing and measuring the extent of translucency.

For the measurement of coronal pulp cavity index RVG images of the respective teeth were imported to the Adobe Photoshop software, a straight line was traced from the cementoenamel junction, which is the division between anatomical crown and root. Coronal Height (CH) was measured vertically straight from the cervical line to the tip of the highest cusp. Coronal Pulp Cavity Height (CPCH) was measured vertically from the cervical line to the tip of the highest pulp horn. The measurements were used to calculate the TCI of each tooth, which will then be calculated as follows:

$TCI = CPCH \times 100/CH$

The measurements were displayed in millimeter.

Results: Age was predicted based on Dentin translucency and Coronal pulp cavity index using linear regression analysis. Also, Pearson's correlation coefficients obtained for both methods were noted. The difference between predicted and actual age was compared for both the indices. Based on the errors of estimated age, prediction cases between 5 years were more in Dentin translucency than coronal pulp cavity index. Moreover, R square value to predict age using dentin translucency (0.689) was higher than coronal pulp cavity index (0.591). Hence Dentin translucency was more suitable to predict age and was a better parameter than Coronal pulp cavity index.

Conclusion: In our study we concluded that dentin translucency a better parameter in age estimation as there was a positive correlation between dentin translucency and age. When tooth the only clinical evidence available age can be determined reliably using the level of root dentin translucency.

Keywords: Age estimation; Dentin translucency; Coronal pulp cavity index

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Introduction

Age is a key factor which is important for preliminary screening procedures. Identification of deceased and living individuals is important for any forensic or medico-legal process. Age estimation has been utilized successfully in the identification and treatment purposes [1].

Proper identification in forensic odontology is required for ethical, humanitarian and official records [2]. Scientific methods to evaluate dental age changes have developed over the last century. Age estimation methods are commonly used in forensic investigations and anthropological studies [3].

In forensic sciences estimation of the chronological age using dentition has been performed by numerous methods. Among these, the most commonly employed scientific method is using the dentition [2]. Although skeletal remains could be used to estimate age, teeth are more reliable maturity indicators as these are least affected from environmental factors, nutritional or endocrine diseases. Moreover, dental tissues are more resistant to thermal, chemical, or mechanical stimuli and could be preserved for long time after death than other developmental tissues [4].

In adults various morphologic, histological, biochemical & radiographic methods have been used to analyze various forms of tooth modifications. In adults age estimation is possible as the teeth undergo structural changes after maturity [2]. The physiological or biological aging is in many cases not related to chronological aging. In this way, a biological marker that is independent of any environmental alteration is required to provide information about the age of an individual [5]. Six criteria had been developed by Gustafson in 1947 which comprised of the parameters including attrition, cementum apposition, gingival recession, thickness of secondary dentin, root resorption and root dentin translucency. In all of these, Root dentin translucency and Secondary dentin deposition are most significant [6]. Because these are least affected by environmental and pathological processes, therefore, we used these biomarkers in our study to estimate age.

In root portion, Dentin translucency is one among the major changes seen with increasing age. Root translucency develops because the dentinal tubules within a root begin to mineralize from the root apex towards crown. Transparency begins in the apical part of the root and proceeds in the coronal direction [1].

In the traditional times, translucency was generally measured with the help of calipers. With the advances in technology, digital evaluation of translucency is often made easily today. Digital method of measuring translucency includes capturing the tooth sections with scanner in life size image tool and subsequent image processing using the Adobe Photoshop software [7].

Digital method is a better approach than conventional method in measuring translucency as it has the provision of verifying the measurements made on life-size images by magnification using the zoom tool within Photoshop [8]. The magnification allows better visualization of the translucent zone. Also, digital approach prevents the damage to thin tooth sections. Further the scanned images can be easily stored and can be kept for future use [7].

Apart from dentin translucency the other parameter which we included in our study for age estimation was secondary dentin deposition. Secondary dentin is a narrow band of dentin bordering the pulp and representing the dentin that is formed after the root completion. It has tubular structure which is almost continuous with primary dentin but contains fewer tubules than primary dentin. Deposition of secondary dentin is a continuous process but is slower than primary dentin. With the advancement of age, the size of the dental pulp cavity is reduced as a result of secondary dentin deposition. Based on the secondary dentin deposition we are going to measure coronal pulp cavity index as scientific studies have shown that coronal pulp cavity index has significant correlation with chronological age [4].

For measuring coronal pulp cavity index radiovisiographic methods have been developed. Digital radiography is considered better option for the patients than conventional methods due to decrease in radiation exposure, better quality of images, less duration of time, and accuracy of measurements. Digital radiographic methods also enable the clinician to save the images for maintaining patient record [9].

The present study was planned for age estimation by using the digital approach of measuring dentin translucency and to compare this method with the radiovisiographic method of measuring coronal pulp cavity index based on secondary dentin deposition and to evaluate a better parameter for age estimation.

Material and Methods

Ethical approval

The study had been approved by the Ethical Committee (PUIEC201210-II-010) of the dental institute. Ethical clearance from PUIEC was sought and there were no ethical issues in the study.

Consent

As per International standard and University standard, patient's written consent has been collected and preserved by the author(s).

Radiovisiographic examination of patient

The radiovisiographic examination of the tooth to be extracted was done. The patients in which RVG was clinically indicated were taken. Digital image of the tooth was obtained and saved for future use in desktop.

Extraction of teeth

The same tooth was then extracted under local anesthesia in the Department of Oral & Maxillofacial Surgery, at Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital, Chandigarh and after extraction the teeth were preserved in 10% formalin at least for 24 h.

Measurement of digital dentin translucency

Following this, the extracted teeth were cleaned of any debris with the help of hydrogen peroxide or under running water and then sectioned using micro motor hand piece, diamond disks and Arkansas stone. The teeth were sectioned longitudinally to 250 μm as close as possible to the central axis of the tooth.

For measuring digital translucency each tooth section was placed on the scanner platen.

Prior to scanning, the scanner setting was verified to be 100% of the original size to ensure life-size scanned images. Scanned images were imported to Adobe Photoshop software for viewing and measuring the extent of translucency.

Measurement of coronal pulp cavity index

After importing the RVG images of the respective teeth to Adobe Photoshop software, a straight line was traced from the cementoenamel junction, which is the division between anatomical crown and root. Coronal Height (CH) was measured vertically straight from the cervical line to the tip of the highest cusp. Coronal Pulp Cavity Height (CPCH) was measured vertically from the cervical line to the tip of the highest pulp horn. The measurements were used

to calculate the TCI of each tooth, which will then be calculated as follows:

TCI = CPCH × 100/CH

The measurements were displayed in millimeter.

Correlation of obtained results

In the present study, estimated age measured by both the methods was correlated with the actual age of the subject.

Results

A total of 100 samples were taken into study. Age was predicted based on Dentin translucency and Coronal pulp cavity index using linear regression analysis. Also, Pearson's correlation coefficients obtained for both methods were noted.

We used the 80/20 split for training and testing as per Pareto Principle (80 samples used for training of the model) i.e., to find the linear regression equations to predict the age using Dentin translucency and Coronal pulp cavity index. After training or formulating the linear regression equation, we tested the model on remaining 20 samples to see how well our model is trained. The difference between predicted and actual age is also compared for both the indices.

A total of 53 males and 47 females were included in our study. Their descriptive statistic of Age, Dentin translucency and Coronal pulp cavity index is given in Table 1 and Figure 1, 2.

Linear regression results based on Dentin translucency

Now we predict the age based on Dentin translucency. We checked the assumptions to apply linear regression as:

1. Variables should be measured at the continuous level. Both age and Dentin translucency are measured at continuous level. So, this assumption is met.

2. A linear relationship between the two variables. We find the correlation coefficient between age and Dentin translucency. The correlation was 0.83 with p-value <0.0001. So, there was significant correlation between age and Dentin translucency means a linear relationship exists between both variables.

3. Residuals or errors of the regression line are approximately normally distributed.

To show this assumption, we drew the Normal P-P plot of regression standardized residual.

Here, data followed a normal distribution, as the little circles were following the normality line shown in Figure 3.

As our all assumptions were fulfilled, we applied the linear regression between age and Dentin translucency as shown in Table 2.

Regression equation or out model becomes:

Age = 15.582 + 7.063* Dentin translucency

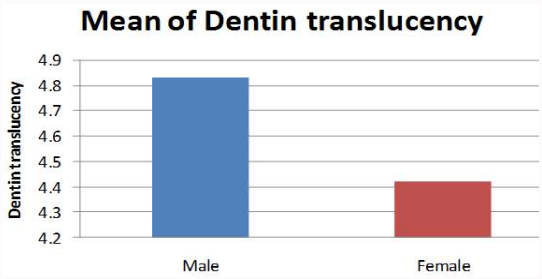

Figure 1: Showing mean of dentin translucency for both male and female.

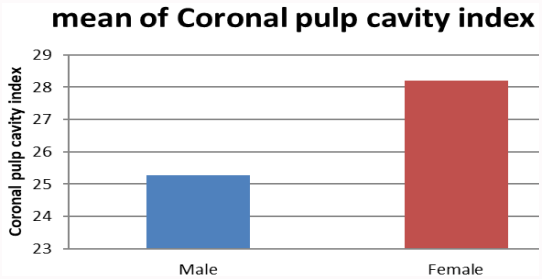

Figure 2: Showing mean of coronal pulp cavity index for male and female.

Table 2: Linear regression between age and Dentin translucency.

Coefficients				
Model	B	Std. Error	t	p-value
(Constant)	15.582	2.784	5.597	0.001
Dentin translucency	7.063	0.537	13.158	0.001
Dependent Variable: Age				

It means with one unit change in Dentin translucency; the prediction of age will increase by 7.063. Also, p-value of Dentin translucency was 0.001 implies that Dentin translucency plays a significant role to predict age.

In model summary of this data, correlation was 0.830 with p-value <0.0001. So, there was significant positive correlation between age and dental translucency.

Coefficient of dispersion (R square) was 0.689. It means 68.90% variability in age was correctly predicted by this model. Scatter plot between age and Dentin translucency shown in Figure 4.

Linear regression results based on Coronal pulp cavity index

We predicted the age based on Coronal pulp cavity index. We checked the assumptions to apply linear regression as:

1. Variables should be measured at the continuous level. Both age and Coronal pulp cavity index were measured at continuous level. So, this assumption was met.

Table 1: Showing descriptive statistic of age, dentin translucency and coronal pulp cavity index.

Gender		Age		Dentin translucency		Coronal pulp cavity index	
	Count	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Male	53	47.83	14.69	4.83	1.9	25.28	11.02
Female	47	48.66	17.66	4.42	1.92	28.19	12.75
Total	100	48.22	16.08	4.64	1.91	26.65	11.9

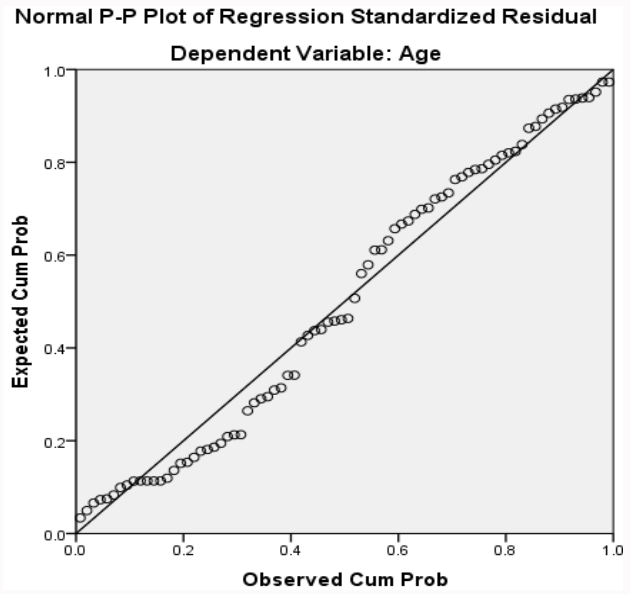

Figure 3: Normal P-P plot of regression standardized residual.

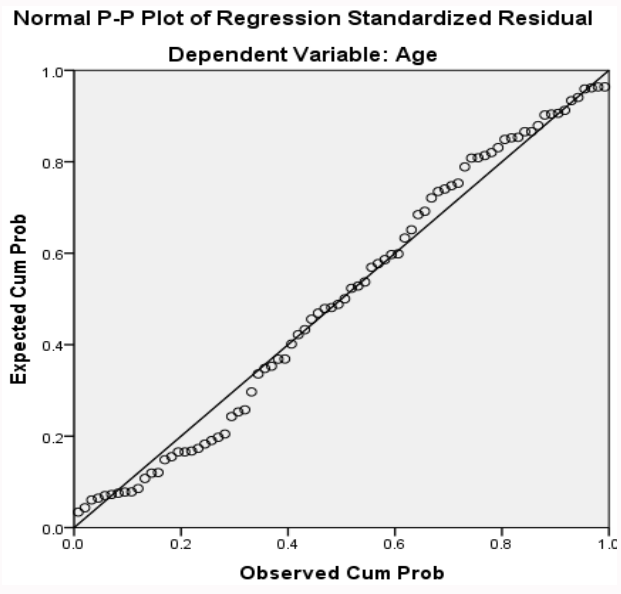

Figure 5: Normal P-P plot of regression standardized residual.

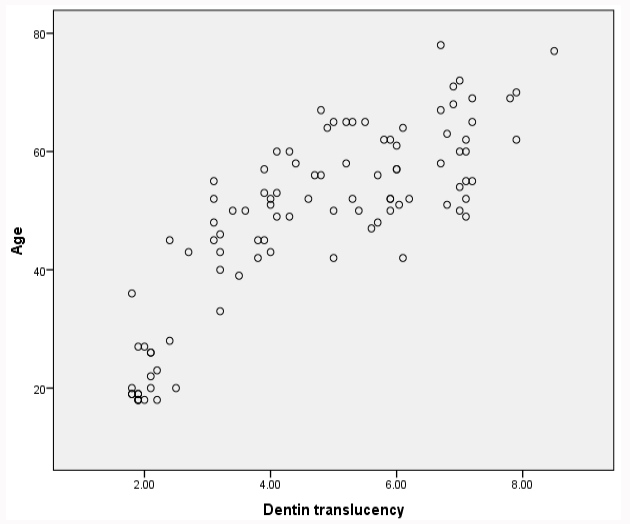

Figure 4: Scatter plot between age and Dentin translucency.

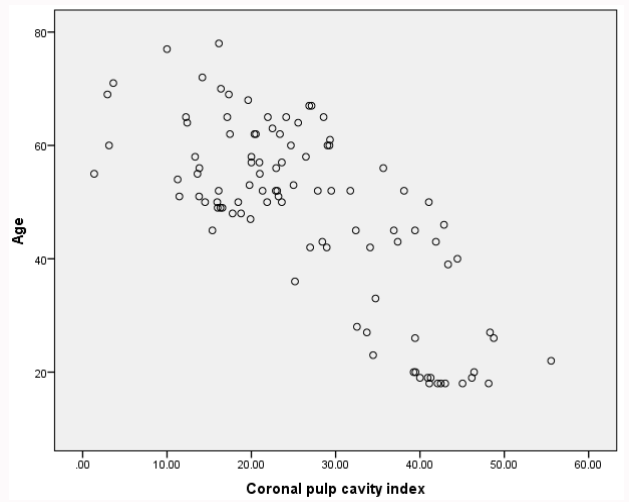

Figure 6: Correlation between age and coronal pulp cavity index.

Table 3: Linear regression between age and Coronal pulp cavity index.

Coefficients				
Model	B	Std. Error	t	p-value
(Constant)	75.453	2.696	27.984	0.001
Coronal pulp cavity index	-1.003	0.095	-10.609	0.001
Dependent Variable: Age				

2. A linear relationship between the two variables. We found the correlation coefficient between age and Coronal pulp cavity index. The correlation was -0.769 with p-value <0.0001. So, there was significant negative correlation between age and Coronal pulp cavity index means a linear relationship exists between both variables.

3. Residuals or errors of the regression line were approximately normally distributed.

To show this assumption, we drew the Normal P-P plot of regression standardized residual as shown in Figure 5. Here, data followed normal distribution, as the little circles were following the normality line.

As our all assumptions were fulfilled, we applied the linear regression between age and Coronal pulp cavity index as shown in Table 3.

Here regression equation or out model becomes:

Age = 75.453–1.003* Coronal pulp cavity index

It means with one unit change in Coronal pulp cavity index; the prediction of age will decrease by 1.003. Also, p-value of Coronal pulp cavity index was 0.001 implies that Coronal pulp cavity index plays a significant role to predict age.

In model summary of this data, correlation was -0.769 with p-value <0.0001. So, there was significant negative correlation between age and Coronal pulp cavity index shown in Figure 6.

Coefficient of dispersion (R square) was 0.591. It means 59.10% variability in age was correctly predicted by this model.

Table 4: Regression equation to estimate the age.

		Errors of estimated age			
Method	**Testing sample**	**± 5 years**	**± 10 years**	**± 15 years**	**± 20 years**
Dentin translucency	20	40% (8/20)	30% (6/20)	20% (4/20)	10% (2/20)
Coronal pulp cavity index	20	15% (3/20)	35% (7/20)	35% (7/20)	15% (3/20)

Now we applied the regression equation to estimate the age of remaining 20 samples using both methods and saw the accuracy of age estimation using both methods shown in Table 4.

So, Dentin translucency is predicting better than Coronal pulp cavity index, as the prediction cases between 5 years is more in Dentin translucency.

Moreover, R square value of to predict age based on denting translucency was 0.689. While R square value of to predict age based on Coronal pulp cavity index was 0.591.

Hence Dentin translucency is more suitable to predict age.

Discussion

Identification of an individual is the first basis of any forensic investigation. Accurate age estimation for any administrative, ethical, and medico legal issues is one among the important parameters in person identification for forensic odontologists. Edwin Saunders suggested that teeth are more reliable indicators of chronological age than any other developmental tissues due to low variation from environmental, nutritional or endocrine factors. Moreover, teeth are more resistant to any thermal, chemical, or mechanical stimuli and could be preserved for long time after death.

In adults various morphologic, histological, biochemical and radiographic methods have been used to analyze various forms of tooth modifications like attrition, secondary dentin deposition, root resorption and dentin translucency etc. Teeth undergo various structural changes after maturity, therefore making age estimation possible in adults [2]. The physiological or biological aging, in many cases, is not related to chronological aging. In this manner, a biological marker independent of any environmental alteration is required to provide information regarding the age of an individual [5]. Six criteria had been developed by Gustafson in 1947 which include attrition, gingival recession, thickness of secondary dentin, cementum apposition, and root resorption and root dentin translucency.

In all of these, Root dentin translucency and Secondary dentin deposition are most significant since these are least affected by environmental and pathological processes [6]. The underlying process behind dentin translucency is as a result of fatty degeneration, physiological hardening during the life-time of the tooth due to increased deposition of the calcific matter, consolidation of the dentinal tubules, equalization of the normally different refractive indices of the tubules and of the calcified dentinal matrix, reduction in diameter of dentinal tubules as a result of increased intratubular calcification and difference in refractive indices between intratubular organic and extra tubular inorganic material is equalized, that results in increased translucency of the affected dentin.

In our study we estimated the age based on the above two parameters i.e., dentin translucency and coronal pulp cavity index and compared to efficacy of each in age prediction. To the best of our knowledge ours is the first study in making this comparison.

In the present study, Dentin translucency was measured by digital method and it was observed that this method can estimate the age within ± 5 years in 40% of the cases which is in contrast to the studies conducted by Ashith B. Acharya et al. [7] and Simranjit Singh et al. [10] in which dentin translucency was measured by both conventional and digital methods and found that the digital method could estimate age to within ± 5 years (20%) and in accordance with the study conducted by Kavitaa Nedunchezhian et al. [1] who measured dentin translucency by using digital method only. The mean age estimated to be was 45.543 with a SD of 20.0446.

The other parameter evaluated in our study was coronal pulp cavity index. In 1925, Bodecker reported the relation between apposition of secondary dentin and chronological age. Since then, various studies suggested that size of dental pulp decreases with increasing age as a result of continuous deposition of secondary dentin, so the measurement of reduction of pulp cavity can be considered as a method to estimate dental age. Based on the secondary dentin deposition coronal pulp cavity index was measured and it was observed that this estimated the age within ± years (15%) which is in contrast to the studies conducted by Supreet Jain et al. [4] and Kusum Singal et al. [11]. In their studies they concluded that the mean calculated age by TCI for premolar was 40.82 ± 12.53 (range 18 to 78 years) and 38.32 ± 11.16 for molar (range 18 to 70 years), and the standard error ranges from 1.66 to 3.33 in males and from 1.76 to 3.66 in females, respectively.

In the present study, linear regression analysis was carried out for age prediction using Dentin translucency and Coronal pulp cavity index. Also, Pearson's correlation coefficients obtained for both methods were noted. The difference between predicted and actual age was compared for both the indices. Based on the errors of estimated age, prediction cases between 5 years are more in Dentin translucency than coronal pulp cavity index. Moreover, R square value to predict age using dentin translucency (0.689) is higher than coronal pulp cavity index (0.591). Hence Dentin translucency is more suitable to predict age and is a better parameter than Coronal pulp cavity index. Moreover, the deposition of secondary dentin is not uniform in contrast to the dentin translucency, so is not able to predict the age to that much accurate level.

Translucency in the apex of root seems to be one of the reliable indicators in the prediction of actual age. Dentin translucency as a parameter to assess age has distinct advantages over the other methods. It is one of the parameter which is least affected by environmental factors. It is one of the simplest methods and is relatively inexpensive to assess and estimate age. This method can be used in cases of mass casualties for the determination of age.

Conclusion

Dentin translucency measurements to determine age have considerably evolved in forensic examinations. Bang and Ramn were the first to use dentin translucency alone for estimating age and reported significant increase in root translucency with age.

In our study we concluded that dentin translucency is a better

parameter in age estimation. One of the limitations of dentin translucency is that it can be better examined on the sectioned teeth only in contrast to coronal pulp cavity index which can be studied on the intact teeth *in vivo*. But as compared to the coronal pulp cavity index, dentin translucency is predicting the age better as there is a positive correlation between dentin translucency and age. When tooth is the only clinical evidence available age can be determined reliably using the level of root dentin translucency.

But further studies can be performed to find the more accurate and reliable method for the estimation of age in living individuals on intact teeth.

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