



ORIGINAL RESEARCH PAPER

Dental Science

DENTAL AGE ESTIMATION BY PULP/TOOTH VOLUME RATIO BASED ON CBCT TOOTH IMAGES: A FORENSIC STUDY

KEY WORDS: Age estimation, pulp/tooth volume ratio, CBCT tooth images.

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ABSTRACT	Introduction:- Age estimation of an individual is important in forensic science. Many dental age estimation has been reported earlier. The volume of dental pulp cavity decreases with increasing age due to deposition of secondary dentin. Hence, pulp cavity volume changes relative to volume of tooth could be useful for dental age estimation.
	Aim and objective:- To estimate the dental age by pulp/tooth volume ratio and to correlate the dental age with the chronological age.
	Materials and methods:- CBCT images with known chronological age between 20 to 50 years. Pulp/tooth volume were measured by third party software and ratio was calculated to correlate with chronological age.
	Result:- The estimated mean dental age is 30.08 and the chronological mean age is 30.29 with standard deviation of 1.79 and 9.45 respectively and statistically no significant difference between mean chronological age and mean estimated age.
	Conclusion:- Dental age estimation by pulp/tooth volume ratio through CBCT tooth images is reliable in this study.

INTRODUCTION

Age estimation is important in forensic medicine and forensic dentistry for identification of deceased victims and for crimes and accidents. Age is one of the essential factors in establishing the identity of the person. Estimation of the human age is a procedure adopted by anthropologists, archaeologists and forensic scientists. Different factors have been used for age estimation but none has withstood the test of time for adults above 25 years. The science dealing with establishing identity of a person by teeth is popularly known as Forensic Odontology or Forensic Dentistry.¹ Dental maturity has played an important role in estimating the chronological age of individuals because of the low variability of dental indicators.² Various methods have been constructed and tested to estimate the age of young individuals.³ Among them are the physical examinations using anthropometric measurements,^{4,5} skeletal maturation,⁶ dental age estimation,⁷ a combination of dental development and anthropometric measurements⁸ and a combination of skeletal and tooth eruption.⁹ Estimation of age at death and determination of sex of the victim or remains are important guides that help in the process of identification. The stages of development can be considered as one of the most dependable indicators in assessing the age of the victim.¹⁰ Even after the complete development of dentition and craniofacial skeleton certain physical, chemical and biological changes takes place which aid in the age estimation.¹¹ Changes that are appreciable with increasing age are attrition, periodontal disease, and deposition of secondary dentine, root translucency, cementum apposition, root resorption, color changes and increase in root roughness.¹² By taking in consideration, these secondary changes in teeth with advancing age various studies were done to estimate the age of an individual. Such research has resulted in multi-factorial methods that help in age estimation. Age estimation, despite several methods still pose to be a never ending challenge, Pulpal reduction caused by apposition of secondary dentin and occlusal tooth wear are used as morphometric parameters in estimating age.¹³ Dental age estimation has received

a considerable attention along with the development of 3D digital images, which is a non-destructive and simple method to get information. It can be used not only in the deceased individuals but also in living individuals.¹⁴ As a novel technology, cone-beam computed tomography not only widely used in clinical of stomatology to help diagnosis, but also used in forensic odontology with better contrast resolution and lower dose. The clinical introduction of cone-beam CT creates new opportunities to get three dimensional tooth radiographs, resulting in a reasonable image quality at a low radiation dose.

AIM AND OBJECTIVE

To estimate the dental age by pulp/tooth volume ratio through CBCT tooth images and correlate the estimated dental age to the chronological age.

MATERIALS AND METHODS

This study includes 50 CBCT scan images, which includes mandibular premolars. These images were obtained from the patients who underwent CBCT examination for various diagnostic purposes. The CBCT scans were acquired using Planmeca Promax Proface 3Dmid machine that uses Romexis software for image reconstructions. CBCT images of intact mandibular premolars, patients aged between 20 to 50 years. The criteria which excluded from this study, Developmental anomalies of teeth, Incompletely erupted tooth, Endodontically treated non vital tooth, any Pathology in premolar area. The particular CBCT volume imported in to dolphin Imaging software as Dicom format image. By using 3D Dolphin imaging software premolar tooth was isolated (figure1) and tooth volume measured by using the software. After tooth volume measurement, pulp canal also isolated (figure2) and volume measured.

STATISTICAL ANALYSIS

Statistical analysis was performed by using SPSS 22 version software to arrive a regression equation from correlation between

pulp/tooth volume ratios in to the chronological age. Regression equation arrived was, $32.239 - 32.071$ (ratio), Dental age Estimation carried out by using the regression formula. Paired sample T test was used to assess the difference between chronological age and estimated dental age. This test used to compare two groups of samples with its mean value and for judging the significance of a sample mean or for judging the significance of difference between the means of two samples.

RESULTS

Table 1 showing the descriptive analysis of number of samples, age, pulp volume, tooth volume and pulp/tooth volume ratio. Out of these samples the maximum tooth volume is 720.3 mm^3 , minimum tooth volume is 231.4 mm^3 and the mean volume of the tooth is 422.23 mm^3 with a standard deviation of 86.23 mm^3 . Maximum pulp volume is 123.8 mm^3 , minimum pulp volume is 9.93 mm^3 and the mean volume of the pulp is 25.52 mm^3 with a standard deviation of 18.49 mm^3 . Pulp/tooth volume ratio shows minimum value is 0.3 maximum 0.27 and the mean value is 0.06 with a standard deviation of 0.040. Regressive analysis of pulp/tooth volume ratio shows R^2 0.019. R^2 measure show close the data are to be fitted regression line. Regressive equation arrived by using R square constant ratio. The regressive arrived equation is by this study is, **Age = 32.239-32.071 (ratio)**. Mean chronological age and mean estimated dental age by using arrived equation are 30.2 and 30.08 with standard deviation of 9.45 and 1.79 respectively. The mean difference between the chronological age and estimated age (Table 2) are 0.21 with standard deviation of 9.29, and the p- value is 0.87. Since the p value is > 0.05 there is no significant difference between mean chronological age and mean estimated age.

DISCUSSION

Age estimation methods are important in forensic science. Techniques reported for age estimation in the literature review is most of them are based on age related changes of bone and teeth. The teeth undergo relatively regular changes due to growth and development. Age estimation by teeth is less reliable, after the completion of eruption pattern. In this study we estimated the age by using the ratio between pulp canal volume and tooth volume of mandibular premolar. The pulp/tooth volume ratios calculated and obtained an equation based on the correlation between the pulp/tooth volume ratios to the chronological age. In this study Total number of samples is 50, minimum age of the samples is 20 years, and maximum age of the sample is 50 years with a mean age of the samples being 30.3 with a standard deviation of 9.45. Out of these samples the maximum tooth volume is 720.3 mm^3 , minimum tooth volume is 231.4 mm^3 and the mean volume of the tooth is 422.23 mm^3 with a standard deviation of 86.23 mm^3 . Maximum pulp volume is 123.8 mm^3 , minimum pulp volume is 9.93 mm^3 and the mean volume of the pulp is 25.52 mm^3 with a standard deviation of 18.49 mm^3 . Pulp/tooth volume ratio shows minimum value is 0.3 maximum 0.27 and the mean value is 0.06 with a standard deviation of 0.040. Regressive analysis of pulp/tooth volume ratio shows R^2 0.019. Regressive equation arrived by using R^2 constant ratio. We arrived equation is **Age = 32.239-32.071 (ratio)**. Mean chronological age and mean estimated dental age by using arrived equation are 30.2 and 30.08 with standard deviation of 9.45 and 1.79 respectively. The mean difference between the chronological age and estimated age are 0.21 with standard deviation of 9.29, and the p- value is 0.87. Since the p value is > 0.05 there is no significant difference between mean chronological age and mean estimated age. A study conducted by Fan Yang et al, in 2006,¹⁵ conducted a study, Dental age estimation through volume matching of teeth imaged by cone beam CT. the aim of this study was to attempt establishing a correlation between the chronological age of a certain individual and the pulp/tooth volume ratio of one of the teeth. 28 single rooted teeth of 19 individuals with well known chronological age were scanned by cone beam CT. then the images were analyzed using custom made software. Linear regression analysis was performed. The results of the analysis showed a moderate correlation between the pulp/tooth volume ratio and biological age with a coefficient of determination (R^2) of 0.29. In this study the pulp/tooth volume ratios varied from 0.0152 to 0.0497 while

in our study pulp/tooth volume ratio varied from 0.03 to 0.27. The equation of the straight line relating age and ratio of pulp/tooth volume is estimated as $\text{Age} = 54.32 - (554.21 \times \text{Ratio})$, while in our study the equation is $\text{Age} = 32.239 - 32.071$ (ratio). In this study the coefficient of determination: $R^2 = 29\%$, while in our study the $R^2 = 19\%$, which is the proportion of the variation in age that can be accounted for by variation in ratio. In another study by conducted by Jagannathan et al.¹⁶ in 2011, studied, Age estimation in an Indian population using pulp/tooth volume ratio of mandibular canines obtained from cone beam computed tomography. This study assessed the suitability of pulp/tooth volume ratio of mandibular canines for age prediction. Volumetric reconstruction of scanned images of mandibular canines from 140 individuals, using computed tomography was used to measure pulp and tooth volumes. Age calculated using a formula reported earlier for Belgian sample. There were no significant differences between the samples in terms of type of tooth or gender of patients. The use of the formula established for the Belgian population in the study group produced a mean age estimation of 15.34 years in 72.8 % of the cases. Age estimates were within ± 10 years of actual age in 27.09 % of the cases. Regression analysis of this study shows statistically significant, but moderate negative correlation between pulp/tooth volume ratio and age and the following linear regression equation arrived as, $\text{Age} = 57.18 + (-413.41 \times \text{pulp/tooth volume ratio})$. Application of this formula to the control group yielded a mean age estimation of 8.54 years with 29/40 (72.5%) estimates lying within \pm ten years of actual age. In contrast, the use of yang's formula in the control group produced mean age estimation of 14.78 years which was significantly different from the obtained formula. While in our study we obtained the formula $\text{Age} = 32.239 - 32.071$ (ratio). In another study conducted by Yayun Wu et al.¹⁷ in 2015 conducted a study, Age estimation from root diameter and root canal diameter of maxillary central incisors in Chinese Han population using cone beam computed tomography. In this study age estimation did from root diameter and root canal diameter of maxillary central incisors radiographs. 420 cone beam computed tomography images of maxillary central incisors chosen and they classified in to seven age groups from 15 to 84 years. Root diameter, root canal diameter and root canal diameter/root diameter ratios obtained by CBCT software. Data of root canal diameter and root canal diameter/ root diameter ratios showed statistically significant correlation with age through correlation and regression analysis while root diameter had no significant correlation with age. In our study also shows no correlation between pulp/tooth volume ratios in to the age. This study conclude dental age estimation is possible using cone beam computed tomography from root and root canal diameter of maxillary central incisors, while in our study we concluded that age estimation is possible by pulp/tooth volume ratios yielded from CBCT tooth images. In another study conducted by Hazha et al.¹⁸ in 2011 studied, Human dental age estimation by calculation of pulp/tooth volume ratios yielded on clinically acquired cone beam computed tomography images of monoradicular teeth. In this study they used CBCT images of monoradicular teeth and ratio between the volume of the pulp and the volume of its corresponding tooth. Linear regression of pulp/tooth volume ratio model was fit with age as dependent variable and ratio as predictor, allowing for interactions of specific gender or tooth type, and the obtained pulp-tooth volume ratios were the strongest related to age, while in our study there was no such relation between the pulp/tooth volume ratios and the age. In another study conducted by Shiva Kumar et al.¹⁹ in 2016 conducted a study, Age estimation using pulp chamber volume of first molars from cone beam computed tomography images in Indian population, they did pulp chamber volume of first maxillary and mandibular molars with the use of CBCT images, assessed the mathematical equation for age estimation. The regression equation obtained from these population, $\text{Age} = 114.445 - 1.441 \times \text{maxillary first molar pulp chamber volume}$ and $\text{Age} = 93.677 - 1.422 \times \text{mandibular first molar pulp chamber volume}$ was statistically significant, hence the pulp volume of first molars is a useful indicator for age, while in our study by using mandibular premolar arrived the equation, $\text{Age} = 32.239 - 32.071$ (ratio), is also shows statistically not significance difference between the predicted age and the chronological age.

CONCLUSION

Dental age estimation by using pulp/tooth volume ratio is reliable in this study by using cone beam computed tomographic images through dolphin imaging software. Mandibular premolars were selected from the age groups between twenty to fifty years. The regression formula arrived from this study was 32.239- 32.071 (pulp/tooth volume ratio). So the estimated dental age by using this formula has shown more than ten years difference in few samples. However, further research on a larger number of populations with variety of ethnic groups is needed for dental age estimation through cone beam computed tomographic images by using different volumetric analysis software for measurement of pulp/tooth volumes more accurately and then estimating the dental ages more precisely.

FIGURES AND TABLES

Figure 1



figure 2

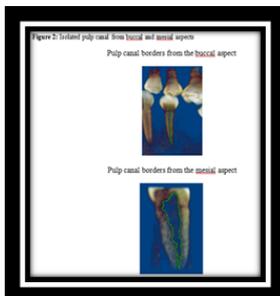


Table 1:- Descriptive analysis of number of samples, pulp tooth volume ratio.

	AGE	T VOL.	P VOL.	ratio
No of Valid	50	50	50	50
Missing	0	0	0	0
Mean	30.30	422.2372	25.527600	.0605
Minimum	20	231.40	9.9300	.03
Maximum	50	720.30	123.8000	.27
Std. Deviation	9.452	86.23336	18.4923570	.04091

Table 2:- Statistical analysis of estimated dental age and chronological age

	Mean	Std. Deviation	Std. Error Mean
Chronological Age	30.2992	9.45188	1.33670
Estimated Age	30.0828	1.79214	25345

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