The Coronal Pulp Cavity Index an aid in age determination -A Cone Beam Computed Tomography Study

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Abstract

Background: The objective of the present study was to assess the accuracy of age estimation from TCI of mandibular molars (except wisdom teeth) of both sides using CBCT images of known age and sex, so that we can apply this method to estimate age in both living individuals and skeletal material of unknown age.

Methods: A cross sectional retrospective study was conducted on a total of 100 CBCT images of subjects who were referred to the department for varied diagnostic purposes of known age and gender. All CBCT images with a fully visible pulp cavity were selected. Two measurements were taken at two different levels. Height of the crown (CH) and height of the coronal pulp cavity (CPCH). Then tooth – coronal index (TCI) for each tooth was calculated as follows: TCI = CPCH X 100 / CH.

Results: Comparison of TCI value between male and female showed no significant difference between the gender. Among the four mandibular molars (lower left and right1stand 2nd molars) 46 and 47 TCI correlates well with age. TCI of 46 has significant prediction of age in female with an R value of 0.426. Inter observer measurements showed a moderate to good agreement of the measures.

Conclusions: TCI method of mandibular teeth was found to be a reliable method for age estimation and not gender determination. CBCT can be used in age determination for forensic purposes as it is non- invasive and also makes it possible to reconstruct the images in different planes showing the anatomical and imaged structures at different planes.

Key words: *Coronal Pulp Cavity Index, Age Estimation, Cone Beam Computed Tomography, Forensic Odontology.*

Introduction

Saunders, in 1837 was the first to publish an article ''Teeth A Test of Age'' implying the importance of teeth in age estimation.[1] In forensic dentistry, age determination using teeth plays a vital role in identification of the victim during mass disaster, criminal cases or social issues. Teeth being the hardest structure also is least resistant to decomposition. Various age estimation methods require extracted tooth by sectioning which is not feasible in a living individual.[2]

The size of the canal and the pulp chamber is inversely proportional to human age. The various age related changes seen associated are odontoblastic vacuolization, reticular atrophy, fibrosis of pulp, hyaline and mucoid degeneration and diffuse calcification. Reparative dentine formation also results in decrease of the pulpal volume due to wasting disease, trauma and restoration.[3]

Age estimation using Tooth coronal index (TCI) has been done using 2 dimensional (2D) radiographs like intra oral periapical (IOPA) using the paralleling technique and orthopantomograph (OPG). It was found to be simple and cost effective than histological methods and could be used in both living and un identified dead for age estimation.[4] Even though, conventional radiographs have been widely as a non-destructive method in the measurement of the pulp chamber. The

disadvantages of these 2D radiographs is that it could have projection errors and the tooth could not be assessed in all directions from a single radiograph. Cone Beam Computed Tomography(CBCT) scans has overcome these disadvantages of 2D imaging modalities as it is also non-invasive. A 3 dimensional (3D) reconstructed image can be obtained which allows us to visualise the morphology of a tooth from all angles without any image distortion.[5]

The present study was done to assess the accuracy of age estimation from TCI of mandibular molars (except wisdom teeth) of both sides using CBCT images of known age and sex, so that we can apply this method to estimate age in both living individuals and skeletal material of unknown age.

Method

A cross sectional retrospective study was conducted on a total of 100 CBCT images of subjects who were referred to the department of Oral Medicine and Radiology for varied diagnostic purposes of known age and gender. The study protocol was approved by the Institutional Ethics committee. The inclusion criteria for selecting the images were those images of patients with healthy teeth without any periapical or periodontal pathologies. The second requirement was that the scanned images were of good diagnostic quality without any artefacts. The images excluded were of those patients with history of trauma or pathology to the teeth and in which the pulp that could not be identified. Images of patients with syndromes or any congenital disorders were excluded. The study images were taken using Promax 3D, Mid version (Planmeca Oy., Helsinki, Finland) CBCT unit. CBCT images were chosen over panoramic images as the measurements were more accurate in terms of magnification and better individual detail could be obtained as there were no superimposition of other structures.

The study images were of 200 subjects (56 females and 44 males). Four mandibular molars (lower left and right,1stand 2ndmolars) excluding the 3rd molars were assessed. The individual tooth was assessed in the axial section and was aligned in the coronal section so that the long axis of the tooth was perpendicular to the lower border of mandible. The measurements were taken in the sagittal section after proper alignment in the axial and coronal section. All CBCT images which with a fully visible pulp cavity were selected. Two measurements were taken at two different levels. Height of the crown (CH) and height of the coronal pulp cavity (CPCH). Then tooth – coronal index (TCI) for each tooth was calculated as follows: TCI = CPCH X 100 / CH.[6]

All measurements were taken using the same machine. To ensure the accuracy of the technique used for measuring TCI detailed reference points were used: Cervical line that connect two landmarks to be measured; the mesial and distal cemento-enamel junction points; and divides the tooth into crown and root. Crown height is the maximum perpendicular distance from the cervical line to the tip of the highest cusp of teeth. While pulp height is the distance from cervical line to the coronal tip of the pulp chamber as shown in Figure 1.

After the procedures of image acquisition and measurement of the height of the crown and the pulp cavity as described above, the volume of pulp chamber was calculated using the region growing tool using the Romexis software as shown in Figure 2.

The measurements were taken using the software–based calibrated measurement tool. All measurements were carried out twice by two observers and the mean was recorded to minimize intra and inter - observer errors.

Statistical Analysis

The statistical analysis of data was done by using excel program for figures and SPSS (SPSS, Inc, Chicago, IL) program statistical package for social science version 20. Independent t-test was used for comparison of gender. Linear regression analysis was used for prediction of age using TCI of 36,37,46 and 47. Interclass correlation coefficient for interobserver variability between 2 observers for the calculated parameters of TCI.

Results

Interobserver variability was carried out using Interaclass correlation coefficient test. The ICC values were 0.730, 0.592, 0.679 for male, female and total population respectively for measurement of TCI (P value of <0.001) which indicated moderate to good agreement of measures.

Independent students t test was used to compare TCI value between male and female and showed no significant difference between the gender (Table1)

Linear regression analysis was performed to predict the age of the individual using the TCI of the first and second molars. Significant association was seen with the TCI values of the tooth 46. Among the four molar teeth 46 and 47 TCI correlates well with age (AGE =13.808+0.131(TCI 46), SEE of 4.25 years and AGE =14.912+0.124(TCI 47), SEE of 4.374 years). TCI of 46 has significant prediction of age in female with an R value of 0.426 and standard estimate of error (SEE) of 3.71 years (AGE =13.651+0.14(TCI 46)). This was the best predictor equation. The other two significant equations were total population equation of 46 and 47. TCI values, with an R value of 0.333 and 0.241 respectively.

Independent t test was done to compare the volume of the pulp among both the sexes and it showed a statistical significant difference between the gender in the mandibular left 1st molar and both molars on the right side with p value of <0.001.

Pulp volume did not show any significant changes among the different age groups. Linear regression analysis shows that the equation Age= 21.243 + 1.127 x ln (pulp volume36) +10.654 x ln (pulp volume 37)-10.721x ln(pulp volume 46) +0.163 x ln(pulp volume 47) has an R value of 0.427 and SEE of 6.27years for prediction of age which was statistically insignificant.

Table I: Independent T Test for comparison of the TCI in male and female

	FEMALE(n=56)		MALE(n=44)		t	df	P VALUE
	Mean	Sd	Mean	sd			
TCI 36	31.999	10.840	34.191	9.049	-1.078	98	0.284
TCI 37	27.966	9.096	26.881	7.479	0.639	98	0.524
TCI 46	31.946	12.357	34.775	10.026	-1.232	98	0.221
TCI 47	25.479	8.818	26.829	8.614	-0.768	98	0.444

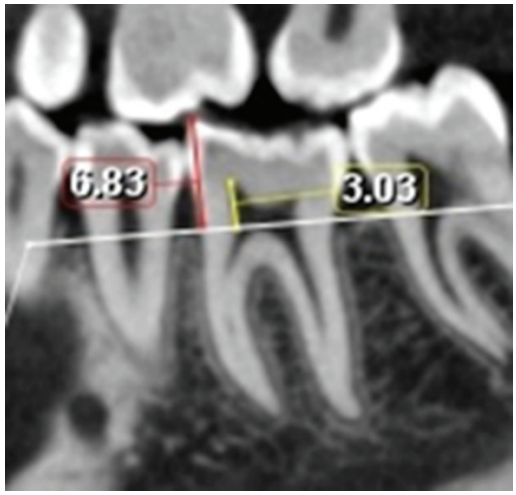

Fig1: Cone beam computed tomography images of the mandibular left molar obtained in the sagittal section shows the measurement of CH (red line) and CPCH (yellow line).

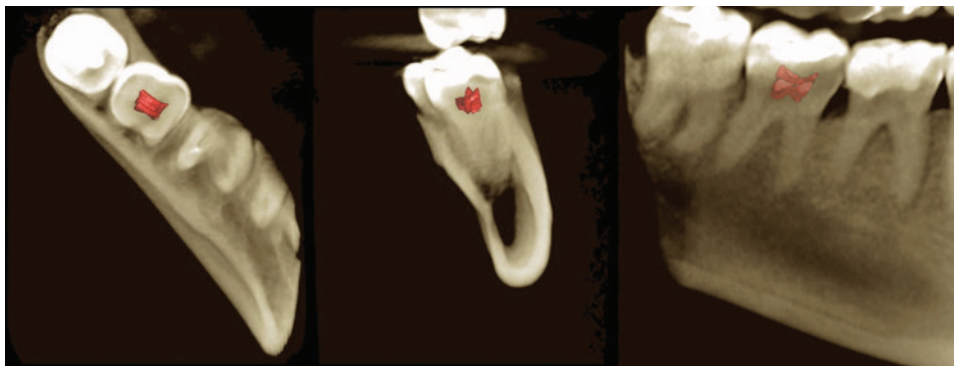

Fig II: Cone beam computed tomography images showing the pulp volume of mandibular left molar obtained in 3D rendered view (axial, coronal, and sagittal views)

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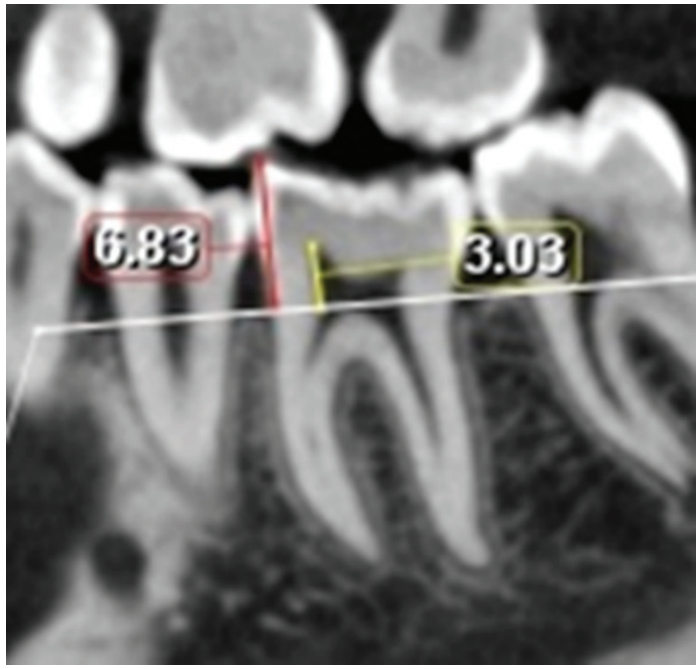

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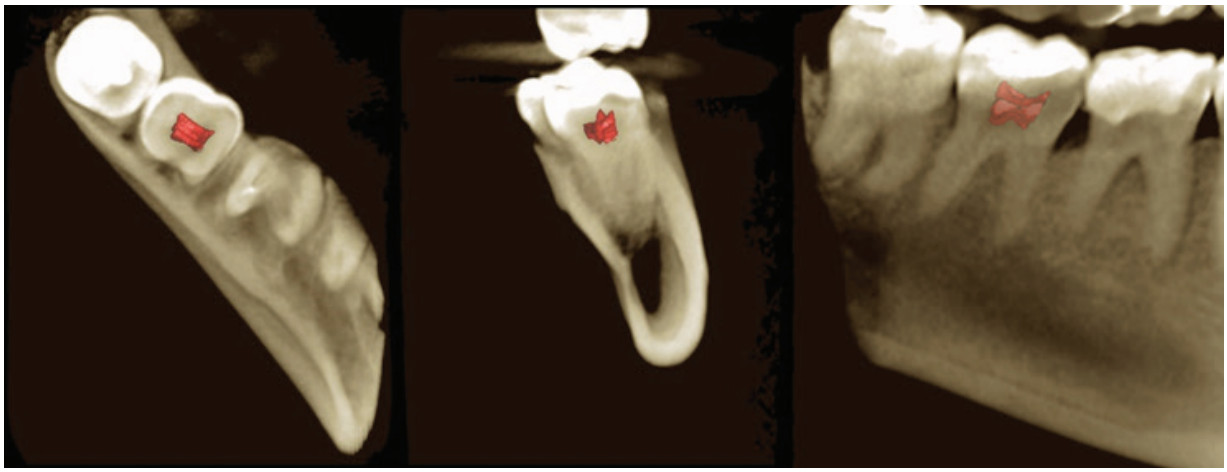

Fig II: Cone beam computed tomography images showing the pulp volume of mandibular left molar obtained in 3D rendered view (axial, coronal, and sagittal views)

Discussion

Tooth coronal index aids in age estimation in people whose age is unknown for a variety of reasons like, minor children are made to work for various reasons, among people who migrate for various reasons, in natural disasters and also from archaeological specimens.

Secondary dentine is formed due to wasting diseases (erosion, abrasions and attrition), ageing, caries etc. which gradually results in the decrease in the pulp volume. Secondary dentine is considered as an age predictor. As age advances the pulpal volume decreases due to apposition of secondary dentine along the dentinal walls.[7] The second reason being that it can withstand damages caused due environmental factors in human remains as it is encased in a harder tissue.[2] This deposition of secondary dentine is not uniform and can vary in different parts in the pulp chamber.[7]

Pulp cavity size decrease as age advances due to secondary dentine getting deposited along the roof and floor thereby reducing the height rather than the width. Pulpal changes were also seen after orthodontic treatment.[8] This decrease in pulpal height acts as a biomarker in age estimation. Sectioning of tooth and radiographs can be used for measuring secondary dentine deposition.[9]

CBCT, a three dimensional imaging modality has advantages over 2 D imaging as it provides images of tooth without magnification, distortion, no superimpositions and images can be viewed in multiple sections at multiple levels. Due to the spatial resolution of CBCT, it can be used to visualise the pulp chamber and anatomic variations. Radiation dose is relatively less when compared to other 3 D imaging modalities.

In our study we measured both coronal and pulp height in sagittal section as it was the ideal section for measuring the maximal height of both tooth and pulp chamber when compared to other sections.

Comparing the TCI value between the genders showed no significant results which was similar to the study done by Drusini AG; Khattab et al.2017 and Nawaya and Burhan 2016; [10,11,12] but was not in accordance with the studies done by Igbigbi P and Nyirenda SK 2005[13], they found that gender had significance influence on age using TCI. Few studies support this theory explaining that it could be due to the influence of estrogen in secondary dentine deposition.[6]

In our study using images taken in CBCT we found that the mandibular right molars (46,47) the TCI values corelated well with age and it was found that the lower right first molar (46) showed a significant prediction of age in females. This was the best predictor in the equation, which was in accordance to a study by Agematsu H et al and EL Morsi DA 2015[14,6]. As R value is positive it shows a positive correlation indicating that

as age increases the index increases and also it was more in females when compared to the males which was similar to the study done by EL Morsi DA 2015 which could be related to the hormonal influence, which could lead to increase in the sequential obliteration of the pulp with growth.[6]

Pulp volume measurement was not statistically significant; it could be because the measurements were taken from images of patients with an age range of 15-30 years. But in our study there was a significant change in the volume of pulp when compared among both sexes. The volume of the pulp chamber was stronger for the males in the present study which was in accordance to a study done by Agematsu H et al. [14].

Conclusion

CBCT plays an important in age as it gives a more accurate picture regarding the dimensions in all planes without with less radiation dose. CBCT could prove useful in forensic odontology as important diagnostic tool in age and sex determination in living and also aid in diagnosing the age and gender of victims in mass disasters. In present study TCI was useful in in age estimation this method was not useful in gender determination.

Ethical Clearance- Taken from, Institutional Ethics Committee Manipal College of Dental Sciences, Mangaluru IEC Protocol Ref No.18070

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Conflict of Interest - Nil

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