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## Short Communication

### **Application of Cone Beam Computed Tomography (CBCT) Tool in the Estimation of Age from Pulp Volume Ratio in Forensic Dentistry: A Short Review**

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#### Abstract

Establishing the biological identity of dental remains or parts is quite challenging in medico-legal cases. In Forensic dentistry professionals, establishing the biological identity by dental regions is one of the most important tasks. Estimation of age is an important aspect of establishing biological identity. Physical examinations, radiographic analysis of ossification of bones, and dental exams are all currently available for predicting the age of departed or living individuals. All these methods have their advantages and limitations. Often comparing these methods provides variation in degrees of accuracy between them. Radiographic tooth growth is a more reliable age assessment as it is mostly genetically determined and thus less susceptible to nutritional and environmental variables. Various scientific research showed that the pulp-to-tooth ratio is as good as a predictor of age and has received more attention. Cone-beam computed tomography systems (CBCT) CBCT in the age estimation attracts forensic personals and researchers compared to micro – C.T. A single scan of a cone-beam C.T. in all three dental axes gives much 3D data on dentition in living individuals in the required area. The present review assessed the role of CBCT in age estimation by pulp volume methods with its merits, demerits, and advantages in the forensic context.

#### 1. Introduction

With age, our body left a distinct signature on our bones. It is quite challenging in medicolegal investigations when the body is in a fragmentary state.<sup>1</sup> When the bones are in an extremely fragmented stage the age assessment from dental parts/remains bears a significant standpoint. Genetics, day-to-day nutrition, and

certain hormonal variables affect the bones and other structures of human beings. Compared to other skeleton components, teeth are less prone to be influenced by external causes. Consequently, chronological age (C.A.) through morphologically and radiologically assessing dentition is becoming increasingly essential in

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human anthropology and bioarchaeology. Dental age determination is dependent on developmental, morphological, and biochemical changes in the teeth.<sup>2</sup>

## 2. Importance of age estimation:

Various components of a man's body are employed for estimating age. Despite this, many body parts lose their original form in catastrophic accidents, burns, or charred remains and cannot be utilised for age estimation.<sup>3</sup> Human teeth last for years after death and can be used to estimate human age.<sup>4</sup> Furthermore, teeth are the least damaged or impacted by their surroundings activities.<sup>5</sup> Estimating the age of teeth in children is pretty straightforward and depends on the teeth's developmental stage.

On the other hand, estimating adult age is a difficult task in forensic medicine. The enamel and dentin make up the tooth, the most rigid portion of the human framework. To evaluate morphological changes, tooth sections are required, which are not feasible in living persons. As a result, most age assessment approaches rely on radiographic imaging.<sup>6</sup> Kvaal et al.<sup>7</sup> developed a technique for estimating age based on secondary dentin deposition and pulp diameters in 1995. The authors concluded that pulp width is highly linked to aging.<sup>7</sup>

## 3. Methods of age estimation:

Calculating age in forensic odontology can be done through Physical examinations, radiography of the left hand, and dental examination. These are all currently available procedures for predicting the age of expired or living people, each with differing degrees of precision. Radiographic tooth growth has been demonstrated to be a more reliable way of age assessment since it is mostly genetically determined and thus less susceptible to nutritional and environmental variables.<sup>8</sup> The radiological age is determined by evaluating the following characteristics as<sup>9</sup>

- Prenatal evaluation of jaw bones - Ultrasound examination can be used to diagnose prenatal jaw bones, which can then be validated by molecular testing using invasive methods, as well as post-delivery radiography and post-mortem, which includes the histomorphological study of cartilage and bone.
- Tooth germs' appearance - Tooth development is the best method for determining age because it has less variability than other development markers. Tooth eruption is one of the most easily observable alterations among the many dynamic

events, from tooth development to tooth shedding. In addition, teeth erupt at reasonably consistent times, which can be used to calculate the mean age of erupting teeth.

- Mineralisation's first visible trace or the start of mineralisation - Mantle dentine is the first mineralised layer of dentin, while circumpulpal dentine is the remaining mass. The odontoblastic cells recede in the area of the dental papilla as the deposition progresses, generating an S-shaped curve identified on a radiograph.
- During the gestation period- mineralisation of several deciduous teeth begins –
- With the crown erupting into the oral cavity - a visual technique can be used to assess age based on the tooth eruption sequence.
- Degree of root completion
- Degree of deciduous tooth resorption - Although root resorption of primary dentition is a vital aspect of dental development, the accuracy of using root resorption to determine age has received little attention.
- Open apices in tooth measurement - The examination of the morphological features of teeth, such as open apices on dental radiographs of older people, is better dependable than the majority of other techniques for estimating age, and we can say that it is the most popular method to determine age in humans.
- Formation of physiological secondary dentine/volume of the pulp chamber and root canals
- Tooth pulp ratio - Dentin and tooth pulp sometimes go through pathological and physiological changes as they are continuously used in the oral cavity and if infected by bacteria. Because breaking teeth to measure these morphological changes is impossible in vivo, age estimation approaches rely on X-ray imaging of the tooth.
- Third molar development and topography - Up until age 16, tooth development and eruption are reasonable measures of age. Only third molar growth can be examined between the ages of 16 and 24. However, there is much heterogeneity, the precision is debatable, and third molars are not generally present.

**4. Cone Beam computed tomography (CBCT) and its use in age estimation:** Two methods are frequently used to identify age: the "Atlas technique," which

compares dental development radiographically (mineralisation) to published guidelines, and the "Scoring technique," which divides the result of the tooth into several phases and assigns grades that are then assessed via data analysis.

Schuller used radiographic techniques for dental examination in 1921.<sup>10</sup> These techniques have also been used to estimate age for over half a century. Kvaal et al.<sup>7</sup> were among the first to recommend utilising radiography to estimate dental age among the adult population. The authors put forth several teeth and pulp length and breadth measurements. Cameriere et al.<sup>11</sup> gave a more or less similar technique for age calculation, but they modified it and assessed the tooth in two areas—the tooth and pulp area. The approach investigated the maxillary canine at first. Still, it expanded to include the second molar and mandibular canine.<sup>12,13</sup> Babshet et al.<sup>14</sup> conducted a similar investigation on mandibular canines in an Indian population.<sup>14</sup> Conversely, radiographs render 3 - dimensional (3D) pulp as a two-dimensional (2D) image. Biological age assessment methods using microfocus computed tomography and 3-D data and ratios of the pulp cavity to all teeth in several single-rooted teeth have been studied.

A newer method for obtaining 3D images of human teeth among living people has been developed using cone beam C.T. (CBCT). It was first introduced in 2000 and allows for 3D imaging of mineralised tissues in small jaw volumes. CBCT depends on cone beam technology and acquires several successive projection images (basis images) in a single scan across the area of interest using a divergent source of ionising radiation and a 2D area detector positioned on a revolving gantry. Because cone beam reconstruction algorithms allow a complete volumetric region to be reconstructed, this area can be refurbished to reveal anatomical details in any plane.

#### 4.1 Examining the volume of teeth

The ages of the adults can be calculated using a radiological measurement and measuring the decrease in pulp cavity size that occurs due to secondary dentine deposition, which is proportionate to their age. Kvaal et al method:<sup>7</sup> Tooth and pulp ratios for the upper and lower six teeth use the maxillary central and lateral incisors, maxillary second premolars, mandibular lateral incisor; mandibular canine; and the first premolar, and will calculate the age using this method. Age is calculated by plugging

the pulp-to-tooth ratios of Kvaal et al.'s age calculation algorithm.

$$\text{Age} = 129.8 - (316.4 \times M) (6.8 \times (W - L))$$

R is pulp-to-root length, P is pulp-to-tooth length, T is tooth-to-root size, A is pulp-to-root width at cemento-enamel junction, C is pulp-to-root width at mid-root level, B is pulp-to-root width at midway between groups C and A were studied for all six teeth with the use of intraoral periapical X rays. In the formula, the average values of proportions except for T (M), the mean value of width ratio B and C (W), and the mean measurement of length ratio P and R (L) were changed.

#### 4.2 Merits of CBCT Tool:

Cone beam computed tomography has opened new paths for getting 3D tooth views, resulting in acceptable image quality at a much less radiation dose (skin dose 1.19 mSv, total dose 20 mSv per examination). Controlled magnification, lack of overlaying, lack of deformations, and multiplanar and 3D presentations that are accessible are all advantages of CBCT over standard radiography treatments, allowing for higher structure transparency and diagnostic performance.<sup>14</sup>

#### 4.3 The drawback of CBCT Tool:

Larger dosages than two-dimensional imaging, difficulty in precisely displaying the interior structure of soft tissues and soft-tissue pathologies, and inability to accurately portray the inner structure of soft tissues and soft-tissue aberrations are some of the disadvantages of CBCT.

#### 4.4 Cone beam computed tomography for assessing age by calculating pulp volume of teeth:

Teeth' growth, biochemical, and morphological changes are used to estimate dental age. Because the mineralisation of dental tissues is a continual activity that may be examined radiographically in adults, morphological changes are preferred. Many techniques dependent on biochemical alterations in teeth, including aspartic acid withdrawal, are time taking, complicated, and invasive, and so are very rarely used. All adult teeth, except for the third molar, have their root formation completed around 16 years of age when their apices close. As a result, age estimation in adults using root development indicators like Demirjian's and Willem's is impossible.

Secondary dentin deposition occurs on both walls of the dental pulp throughout the developmental process of teeth after maturation, which minimises the size of the pulp cavity over time.

As a result, the degree of pulp cavity size reduction can be used as an excellent morphological criterion for determining age in adults. Tooth extraction and incision, as well as imaging techniques, can be used to determine secondary dentin deposition. Deposition of Secondary dentine can be seen and assessed using oral panoramic and intra-oral periapical radiography. On the other hand, these radiographic modalities have the drawback of being two-dimensional and presenting a distorted image. In 2-D images, there is overlapping of anatomical structures, and the problem with radiographical geometry and amplification can also be seen, so they fail to offer reliable measurements.<sup>15</sup> Studies have used three-dimensional modalities to overcome the constraints of two-dimensional imaging for age estimates. For example, CBCT (cone beam computed tomography) provides 3-D images, an accurate and appropriate method for calculating dental pulp volume.

#### **4.5 Interpretation of the image procured by CBCT:**

Planmeca Romexis is a software of Helsinki, Finland, used to analyse the CBCT pictures. With the help of software, the crown volume (CV) is estimated by tracing a line from the cementum-enamel junction to the incisal edges of the tooth in all three planes, which can be axial, sagittal, or coronal. The grayscale criteria for all three structures, enamel, dentin, and pulp, allows the tooth crown to be segmented automatically. The tooth crown pulp volume (CPV) is calculated in the same way but with three planar axes marking the area from the CEJ to the pulp chamber roof and a grayscale threshold that divide the coronal pulp. With the help of 3D pictures, the software estimates the crown (CV) and pulp chamber (CPV) volumes. And with the use of software, each tooth's pulp chamber/crown volume ratio is measured.<sup>16</sup>

#### **4.6 Efficacy of CBCT tool in age estimation:**

Pinchi et al.<sup>17</sup> said that their existing method, based on the geometric estimation of the various portions of the tooth, showed that it has the best accuracy in age assessment for age groups between 30 and 59 years. It was seen that age estimation error was more or less comparable to what was reported by other dental methods for different age cohorts. The Volume measurements of the pulp chamber/crown ratio (up to cemento-enamel junction) are helpful in any gender for age assessment. It is quicker and equally reliable than pulp cavity/tooth ratio investigation, as per Asif et al.<sup>18</sup> Gulsahi et al.<sup>19</sup> say that the pulp volume to tooth volume does not depend on gender and found out

that calculating it on anterior maxillary teeth is more reliable than calculating it on other teeth. Teeth with decay, fillings or crown fillings, periapical illnesses, or unidentifiable pulps were excluded from these studies since they obstruct the physiological events in healthy teeth. The use of cone beam computed tomography (CBCT) in today's time to calculate the pulp/tooth volume ratio is suggested for two reasons: (1) The measurement of Volumes of the pulp chamber and tooth has more weightage than area ratio calculations, even secondary dentine deposition is not identical across all pulp surfaces, and thus measurements of projected areas may give an erroneous impression of the degree of this procedure; (2) CBCT is an accurate technique for investigating the anatomical structure of the pulp chamber and root canal space, offering three-dimensional volumetric data of the tooth.<sup>20</sup> Some researchers estimated age from radiological evaluation of root developmental stages of molars.<sup>21</sup>

In the Indian context, it is necessary to add CBCT guidelines to the dentistry education syllabus for the best use of CBCT. Recently, NMC implemented a competency-based education system for medical graduates that can help them in developing their skills in applied aspects also.<sup>22</sup> With technological advancement, training and skill development in CBCT techniques could be an additional option for medical graduates.<sup>23</sup> It is also the need of the hour that all prescribing forensic dentists, clinicians, and future researchers keep themselves trained in the latest CBCT procedure and its interpretation for maximum benefits in the medicolegal and clinical context in India.<sup>24</sup>

#### **5. Conclusion**

Evaluating the pulp space opens up new possibilities for determining dental age. The calculation of secondary dentine deposition is commonly used and acts as an effective procedure. This apposition is a constant, age-related process that changes the pulp chamber's size and is altered in pathological situations (for example, caries). The size of the pulp chamber has been studied using a variety of approaches involving tooth cross-sections and radiography. The pulp-tooth area ratio of upper canines has been calculated using oral ortho-panoramic and intraoral periapical radiography. Radiographs have the disadvantage of being 2-D projections which go through significant amplification and deformational errors. As there are specific errors in 2D images, it is suggested that teeth' mesiodistal

and buccolingual measures should be calculated together. The best and most accurate approach for estimating the pulp-tooth volume ratio is Cone Beam computed tomography (CBCT)

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### References:

- Ahmad N, Purkait R. Sex Estimation from the Shaft Fragment of Humerus Bone from Samples of Central Indian Skeletal Remains. *J Forensic Med Sci Law*. 2021; 30(2):4-9
- Johanson G. Age determination from teeth. *Odont Revy*. 1971; 22:1–126.
- Farhadian M, Salemi F, Saati S, Nafisi N. Dental age estimation using the pulp-to-tooth ratio in canines by neural networks. *Imaging Sci Dent*. 2019; 49(1):19-26.
- Igbigbi P, Nyirenda SK. Age estimation of Malawian adults from dental radiographs. *West Afr J Med*. 2006; 24(4):329–33.
- Mathew DG, Rajesh S, Koshi E, Priya LE, Nair AS, Mohan A. Adult forensic age estimation using mandibular first molar radiographs: a novel technique. *J Forensic Dent Sci*. 2013; 5(1):56-9.
- Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam C.T. *Forensic Sci Int*. 2006; 159(1):78–83
- Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. *Forensic Sci Int*. 1995; 74(3):175–85.
- Duangto P, Janhom A, Prasitwattanaseree S, Mahakkanukrauh P, Iamaroon A. Age Estimation Methods in Forensic Odontology. *J Dent Indones*. 2016; 23(3):74-80.
- Panchbhai AS. Dental radiographic indicators, a key to age estimation. *Dentomaxillofac Radiol*. 2011; 40(4):199-212.
- Wood RE. Forensic aspects of maxillofacial radiology. *Forensic Sci Int*. 2006; 159 (Suppl 1): S47–55.
- Cameriere R, Ferrante L, Cingolani M. Variations in pulp/tooth area ratio as an indicator of age: A preliminary study. *J Forensic Sci*. 2004; 49:317–9.
- Cameriere R, Ferrante L, Cingolani M. Precision and reliability of pulp/tooth area ratio (R.A.) of the second molar as indicator of adult age. *J Forensic Sci*. 2004; 49:1319–1323
- Cameriere R, Ferrante L, Belcastro MG, Bonfiglioli B, Rastelli E, Cingolani M. Age estimation by pulp/tooth ratio in canines by peri-apical x-rays. *J Forensic Sci*. 2007; 52:166–70.
- Babshet M, Acharya AB, Naikmasur VG. Age estimation in Indians from pulp/tooth area ratio of mandibular canines. *Forensic Sci Int*. 2010; 197(125):e1–4.
- Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam C.T. *Forensic Sci Int*. 2006; 159(1): S78-S83
- Molina A, Bravo M, Fonseca GM, Márquez-Grant N, Martín-de-las-Heras S. Dental age estimation based on pulp chamber/crown volume ratio measured on CBCT images in a Spanish population. *Int J Leg Med*. 2021; 135:359-64.
- Pinchi V, Pradella F, Buti J, Baldinotti C, Focardi M, Norelli G.A. A new age estimation procedure based on the 3D CBCT study of the pulp cavity and hard tissues of the teeth for forensic purposes: A pilot study. *J Forensic Leg Med*. 2015; 36:150–7.
- Asif MK, Nambiar P, Mani SA, Ibrahim NB, Khan, IM, Sukumaran P. Dental age estimation employing CBCT scans enhanced with Mimics software: Comparison of two different approaches using pulp/tooth volumetric analysis. *J. Forensic Leg Med*. 2018; 54:53–61.
- Gulsahi A, Kulah C.K, Bakirarar B, Gulen O, Kamburoglu K. Age estimation based on pulp/tooth volume ratio measured on cone-beam C.T. images. *Dentomaxillofac Radiol*. 2018; 47(1): 20170239.
- Neelakantan P, Subbarao C, Subbarao CV. Comparative evaluation of modified canal staining and clearing technique, cone-beam computed tomography, peripheral quantitative computed tomography, spiral computed tomography, and plain and contrast medium-enhanced digital radiography in studying root canal morphology. *J Endod*. 2010; 36:1547–51.
- Ramkumar J, Ganesh R, Naveen N. Age Estimation From Radiographic Evaluation of Various Developmental Stages of Maxillary Third Molars and its Associated Gender Variation. *J Forensic Med Sci Law*. 2022;31(2):33-37.
- Deokar RB, Patil SS. Competency based Medical Education curriculum for Undergraduates Forensic Medicine Perspectives. *J Forensic Med Sci Law*. 2019; 28(2):1-2.
- Deokar RB, Patil SS. Avenues in Forensic Medicine. *J Forensic Med Sci Law*. 2023;32(2):1-3.
- Parveen S, Kulkarni U, Mascarenhas R, Shetty R. Awareness and practice of ethics and guidelines with cone-beam computed tomography prescription in orthodontics. *J Indian Orthod Soc*. 2019; 53:49-56.