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# Age Estimation by Antegonial Angle, Depth Measurement and Tooth Coronal Index by Digital Panoramic Radiography: A Retrospective Study

**Shilpa Shaliputra Magar**

MDS, Lecturer, Endodontics section Department of Restorative dental sciences, College of Dentistry, Jouf University, Kingdom of Saudi Arabia

**Shaliputra Pralhad Magar**

MDS, Lecturer, Oral Radiology, Department of Oral and Maxillofacial Surgery and Radiology, College of Dentistry, Jouf University, Kingdom of Saudi Arabia

**Priyadarshini Rangari**

MDS, Associate professor, Department of Dentistry, Sri Shankaracharya Institute of Medical Sciences, Bhilai, Durg, Chhattisgarh, India

**Bibhu Prasad Mishra**

MDS, Senior lecturer, Department of Oral and Maxillofacial Surgery, Hi- Tech Dental College and hospital, Bhubaneswar, Odisha, India

**Amarpal Kour Chhabada**

BDS, Utkal University, Gandhi Dental College, Bhubaneswar, Odisha, India

**Abstract**---Background: Estimating age in alive humans is a recent area undergoing exploration in forensic sciences. The relationship of pulp size and age as seen in radiographs is utilized by TCI (tooth coronal Index) for age estimation. Aim: The present study was carried out to use a cost-effective and simple method of estimating age using morphometric analysis of dental pulp. Methods: The study was completed on 160 subjects classified into 4 groups based on age including 21-30, 31-40, 41-50, and 51-60 years, followed by capturing digital radiographs (either OPG/ RVG). Morphometric analysis was then done using antegonial angle, depth, and TCI for age estimation, and the results were made. Results: Coronal height of pulp, coronal height in the millimeters, and TCI on OPG were seen as  $8.24\pm 1.02$ ,  $2.55\pm 0.66$ , and  $30.48\pm 6.59$  respectively for 2nd premolar. For 1st molars, respective values of TCI, the coronal height of pulp, and

coronal height were seen as  $29.16 \pm 6.43$ ,  $2.65 \pm 0.68$ , and  $9.01 \pm 1.05$  respectively. Antegonial depth for the right side was  $2.39 \pm 1.17$ , whereas, for the left side, it was  $2.28 \pm 1.09$ . The result was statistically significant with  $p=0.015$ . On RVG assessment, TCI on RVG and OPG was seen as 31.87% (n=51) and 31.25% (n=50) respectively in the complete population of 160 subjects. On combined assessment on RVG and OPG, the age was predicted to be 38.75% (n=62). In age prediction, in test data (n=40), age prediction in  $\pm 5$  years, on RVG, OPG, and combined RVG and OPG, the values were 40% (n=16), 37.5% (n=15), and 42.5% (n=17) respectively. Conclusion: The present study concludes that a correlation between TCI and age was not found using RVG/OPG. However, a more significant correlation was seen in the combined effect of antegonial depth and angle combined with age.

**Keywords**---tooth coronal index (TCI), antegonial angle, antegonial notch, radiovisiography (RVG), orthopantomogram (OPG).

## Introduction

Uninterrupted and ends with death. Age evaluation/ determination is a recently exposed arena used in forensic sciences which are researched extensively. Assessing criminals and legal cases rely largely on age assessment leading to its increased importance as a diagnostic tool with the exponential crime increase in India. Age estimation is a long-used technology in forensic odontology where the assessment of age from the tooth of a deceased person is an important parameter.<sup>1</sup>

Human teeth being harder than bone and are resistant to natural degradation, and hence, are durable. Owing to this fact, human teeth serve as reliable evidence in forensic odontology as fossils. Following complete tooth eruption and mineralization, it constitutes one of the most stable structures in the human body. Chronological age assessment can be judiciously judged using its development and regressive changes. Also, human teeth are resistant to a variety of factors leading to disintegration, and show a very slow disintegrating phenomenon, making human teeth a reliable tool for estimating age. Age estimation using teeth and dental tissue dental tissues utilize various methods divided into 2 main categories namely radiologic and morphologic assessment. These 2 categories are further divided into biochemical, histologic, and clinical methods.<sup>2</sup>

An easy method of estimating age relies on secondary dentin deposition evaluation as depicted on radiographs. Size of dental pulp and age interrelationship is used for age estimation using the method Tooth Coronal Index<sup>3</sup>. Apart from the tooth, other craniofacial structures that can be used to assess human age are various anatomic structures of the mandible. Morphologic changes seen in the mandible depend on the age and dental status of the subject. One such morphologic change seen in mandible border is the curving of the mandibular inferior border towards the upward side anterior to gonion (angular

process) and is termed as antegonial notching observed at junction of ramus and mandibular body.<sup>4</sup> Changes in the pulp chamber size and deposition of secondary dentin can be assessed on conventional radiographs making their use more evident in age determination.

However, conventional radiography has various shortcomings including long-duration storage, image measurements, image transfer, and/or processing errors. These shortcomings are largely reduced using dental digital radiography techniques that came into play in the 1980s. The use of digital radiography has become more practical and precise with better software and silicon technology making its use rapid and easy.<sup>5</sup> The storage and digitization of intraoral periapical and panoramic radiographs allows better image assessment, with the added advantage of allowing accurate and precise measurement of teeth morphologic parameters without image distortion. These qualities allow statistical analysis and are reliable. Very few studies in the literature attempted to assess age determination using RVG/ OPG and morphometric analysis of dental pulp.<sup>6</sup> Hence, the present clinical trial was conducted to devise a cost-effective and simple method for age estimation using morphometric dental pulp analysis and to assess changes in antegonial depth and angle to predict age using antegonial parameters with TCI.

### **Material and Method**

The present study included subjects reporting to the outpatient department of the institute. The study was performed after obtaining clearance from the concerned Ethical committee. Informed consent was obtained after explaining the study design to each subject individually. A total of 160 subjects included comprised both males and females within the age group of 20 years to 60 years and the mean age of  $39.8 \pm 1.4$  years. After final inclusion, the subjects were divided into four groups having  $n=40$  subjects each, and the 4 groups had age groups of 21-30 years, 31-40 years, 41-50 years, and 51-60 years. Following which each subject underwent clinical examination followed by digital radiography and measurements. The clinical examination was carried out by a single experienced examiner using a mouth mirror and probe. The study assessed first molars and second premolars as index teeth, and hence, their presence was evaluated on clinical examination. The clinical examination assessed if index study teeth were either restored or carious which were excluded. The exclusion criteria for the study were teeth with severe periodontal disease. The presence of antagonist teeth was also considered as a necessary criterion for the present study.

Following assessment, demographic data of study subjects was noted followed by digital radiography. The study subjects were briefed about the radiographic procedures. A standard panoramic radiographic examination of the selected individuals was conducted using the ORTHOPHOS XG X-ray system (version 2.53 Sirona, Germany). The measurements were taken using "Sidexis" software. Concerning RadioVisioGraphy (RVG), patients were asked to sit upright on the conventional dental chair to decrease the artifacts that could be cast onto the image. The occlusal plane was aligned so that it was parallel to the floor. The radiographs of second premolars and first molars were taken from the same side as that of the side of the orthopantomogram from which readings were taken. For

periapical view size #2sr CCD based sensor (SUNI- RAY) was used with sensor dimensions 43.5 x 31.5 mm. Radiographs were taken by paralleling angle technique. The measurements were taken using “Sun Ray” software.

### **Parameters analyzed**

#### **Morphometric analysis on radiographs**

The digital radiography allows both curvilinear and linear measurements between either multiple points or any two points. First Molar: A straight line traced between the cemento-enamel junctions is the division between the anatomical crown and root. The crown height (CH) was measured vertically from the cervical line to the tip of the highest cusp (Moss et al, 1967). The coronal pulp cavity height (CPCH) was measured vertically from the cervical line to the tip of the highest pulp horn (Ikeda et al., 1985). This measurement provided the tooth-coronal index (TCI) for each tooth which was then calculated as follows:  $TCI = CPCH \times 100/CH$ . As shown in Fig. 1: Antegonial Depth and Antegonial Angle with TCI of 2<sup>nd</sup> premolar

Second Premolar: Measurements similar to those in the first molars were proposed to be made in the second premolar as well. Antegonial angle measurement: The antegonial angle measurement was done by tracing two lines parallel to the antegonial region intersecting at the deepest point of the antegonial notch. Antegonial depth measurement was taken as the distance along a perpendicular line from the deepest point of the notch concavity to a tangent through the inferior border of the mandible. The collected data were subjected to statistical evaluation for results formulation.

### **Results**

The present clinical trial was conducted to devise a cost-effective and simple method for age estimation using morphometric dental pulp analysis and to assess changes in antegonial depth and angle to predict age using antegonial parameters with TCI in 160 subjects on digital radiography. The demographic characteristics of the study subjects are summarized in Table 1. The number of subjects was uniformly distributed in the study groups with 25% (n=40) subjects each and for gender, there were 63% males and 37% females, showing a ratio of 1:0.57. Concerning analyzing the parameters seen in teeth based on digital OPG. The values of assessed coronal height of pulp, coronal height in the millimeters, and TCI on OPG were seen as  $8.24 \pm 1.02$ ,  $2.55 \pm 0.66$ , and  $30.48 \pm 6.59$  respectively for 2<sup>nd</sup> premolar. For 1<sup>st</sup> molars, respective values of TCI, the coronal height of pulp, and coronal height were seen as  $29.16 \pm 6.43$ ,  $2.65 \pm 0.68$ , and  $9.01 \pm 1.05$  respectively as shown in Table 2.

Similarly, the present study also evaluated parameters seen in teeth based on digital RVG, the assessed values were the coronal height of pulp and coronal height in the millimeters, TCI, and the results are depicted in Table 2. The respective values of TCI, the coronal height of pulp, and coronal height in the 2<sup>nd</sup> premolar were  $28.84 \pm 6.53$ ,  $2.35 \pm 0.76$ , and  $7.98 \pm 0.92$  respectively. These values for 1<sup>st</sup> molars on RVG were  $26.93 \pm 6.41$ ,  $2.34 \pm 0.62$ , and  $8.52 \pm 1.02$  respectively. The range of minimum to maximum for each parameter is also described in Table

2. Antegonial measurements including antegonial depth and angle were assessed on the OPG. Concerning antegonial depth, the results showed that antegonial depth for the right side was  $2.39 \pm 1.17$ , whereas, for the left side, it was  $2.28 \pm 1.09$ . The result was statistically significant with  $p=0.015$ . The antegonial angle assessed in degrees showed that the angle on the right side was  $159.55 \pm 7.95$ , and the left side was  $160.04 \pm 7.87$  with a statistically non-significant difference ( $p=0.188$ ) as depicted in Table 3.

The present study also estimated age in the study subjects on second premolars using different models and the results are shown in Table 4. The results showed that on RVG assessment, TCI was evaluated and TCI on RVG and OPG was seen as 31.87% (n=51) and 31.25% (n=50) respectively in the complete population of 160 subjects. On combined assessment on RVG and OPG, the age was predicted to be 38.75% (n=62). In age prediction, in test data (n=40), age prediction in  $\pm 5$  years, on RVG, OPG, and combined RVG and OPG, the values were 40% (n=16), 37.5% (n=15), and 42.5% (n=17) respectively (Table 4). The age prediction was non-significantly better using antegonial methods in combination with TCI compared to TCI alone.

## Discussion

The present clinical trial was conducted to devise a cost-effective and simple method for age estimation using morphometric dental pulp analysis and to assess changes in antegonial depth and angle to predict age using antegonial parameters with TCI in 160 subjects. This criterion is an important tool these days owing to the increase in interest in solving criminal cases with help of forensic techniques. Also, using radiographs for morphometric assessment is more reliable than other methods of age estimation. The present study utilized digital pantomograms and RVG (Intraoral periapical radiographs). Digital radiography has the advantages of better storage and image measurements. OPG has the advantage of showing both the arches at the same time. The present trial used second premolars and first molars as index teeth owing to clear delineation of pulp chamber in these teeth followed by age determination as also described in previous studies. Then, digital radiographs and OPG were compared for estimating age with the help of TCI.

Amongst the total sample, 31.5% of the subject's age was estimated within  $\pm 5$  years using OPG. These findings were in agreement with the previous study by P. S. Igbigbi et al<sup>7</sup> in 2005 where authors estimated 47.76% of cases within  $\pm 5$  years. With concerned gender-based age estimation, the difference in age estimation was estimated using RVG and OPG. The results showed that on RVG assessment, TCI was evaluated and TCI on RVG and OPG was seen as 31.87% (n=51) and 31.25% (n=50) respectively in the complete population of 160 subjects. On combined assessment on RVG and OPG, the age was predicted to be 38.75% (n=62). In age prediction, in test data (n=40), age prediction in  $\pm 5$  years, on RVG, OPG, and combined RVG and OPG, the values were 40% (n=16), 37.5% (n=15), and 42.5% (n=17) respectively (Table 4). The age prediction was non-significantly better using antegonial methods in combination with TCI compared to TCI alone. Hence OPG is a better predictor of age in females.

In this study, statistically significant differences were obtained between the mean

antegonial angle and antegonial depth measurements concerning gender and age in younger age groups 21-30 years and 31-40 years. These findings contrasted the results of the study by Sujoy Ghosh et al<sup>8</sup> in 2010 and Dutra et al<sup>9</sup> in 2004 where no statistically significant correlation was seen in the mean antegonial angle and depth measurement concerning age, whereas, a decrease in the antegonial angle was observed.

On the comparative evaluation of antegonial depth and antegonial angle for the right and left sides, the values were higher on the left side compared to the right side. However, the difference was statistically non-significant for antegonial angle, whereas, for antegonial depth, the difference was statistically significant. Mean antegonial depth was higher on the right side when compared to the left side. These findings were consistent with the findings of Maya S et al<sup>10</sup> in 2002 where authors reported high values on the right side. Finally, age-related changes are reliable biomarkers for estimating age. Teeth show the physiological, genetic, chewing pattern, and biological factors in altering the anatomy of human teeth. The complexity of human teeth largely depicts the changes related to age. Hence, appropriate age assessment with accuracy in adult humans needs further probation.

### **Conclusion**

Within its limitations, the present trial concludes that the correlation of the Tooth Coronal Index with age in different age groups is significant in the premolars irrespective of gender. However, a statistically non-significant difference was seen in age correlation using RVG and OPG with Tooth Coronal Index. However, the combined result using RVG and OPG were more significant concerning antegonial depth, antegonial angle, and tooth coronal index. In the younger age group, a significant correlation was seen in antegonial depth increase and antegonial angle. Antegonial depth was less in females, whereas, antegonial angle was more in comparison to males. Hence, the present study depicts antegonial depth and angle that can be used in forensic medicine to determine gender. However, the study had few limitations including smaller sample size, short monitoring period, and geographical area biases. Hence, further longitudinal trials with a longer monitoring period and larger sample sizes are needed to reach a definitive conclusion.

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## Appendix

Table 1  
Demographic characteristics of the study subjects

Characteristics	Range	Percentage (%)	Number (n)
Study Groups based on age (years)	21-30	25	40
	31-40	25	40
	41-50	25	40
	51-60	25	40
Gender	Males	63.12	101
	Females	36.87	59

Table 2  
Different parameters of index teeth as assessed on OPG and RVG in the study subjects

Tooth assessed	Parameter	Mean±S.D	Range (min-max)
1 <sup>st</sup> Molar (on OPG)	Tooth Coronal Index	29.16±6.43	11.84-43.72
	Coronal Pulp Height (mm)	2.65±0.68	0.99-4.18
	Coronal Height (mm)	9.01±1.05	6.8-11.4
2 <sup>nd</sup> Premolar (OPG)	Tooth Coronal Index	30.48±6.59	14.72-50.57
	Coronal Pulp Height (mm)	2.55±0.66	1.2-4.2
	Coronal Height (mm)	8.24±1.02	5.52-11.06
1 <sup>st</sup> Molar (RVG)	Tooth Coronal Index	26.93±6.41	11.13-42.00
	Coronal Pulp Height (mm)	2.34±0.62	0.96-3.98
	Coronal Height (mm)	8.52±1.02	2.44-10.68
2 <sup>nd</sup> Premolar (RVG)	Tooth Coronal Index	28.84±6.53	16.59-50.04
	Coronal Pulp Height (mm)	2.35±0.76	1.2-4.7
	Coronal Height (mm)	7.98±0.92	5.2-10.1

Table 3  
Antegonial Depth and Antegonial Angle in the study subjects

Antegonial assessment	Side	Mean±S.D	Range (min-max)	p-value
Antegonial Depth (mm)	Right Side	2.39±1.17	0.24-5.28	0.015
	Left Side	2.28±1.09	0.5-5.2	
Antegonial Angle (degree)	Right Side	159.55±7.95	140-175.5	0.188
	Left Side	160.04±7.87	139-189	

Table 4  
Age prediction in the study subjects on 2nd premolars using different models

Assessment Method	Parameters Assessed	Prediction in ± 5 years % (n)	
		Complete Data(n=160)	Test Data(n=40)
RVG	TCI	31.87 (51)	40 (16)
OPG	TCI	31.25 (50)	37.5 (15)
Both RVG and OPG	Antegonial angle and Depth, TCI	38.75(62)	42.5 (17)

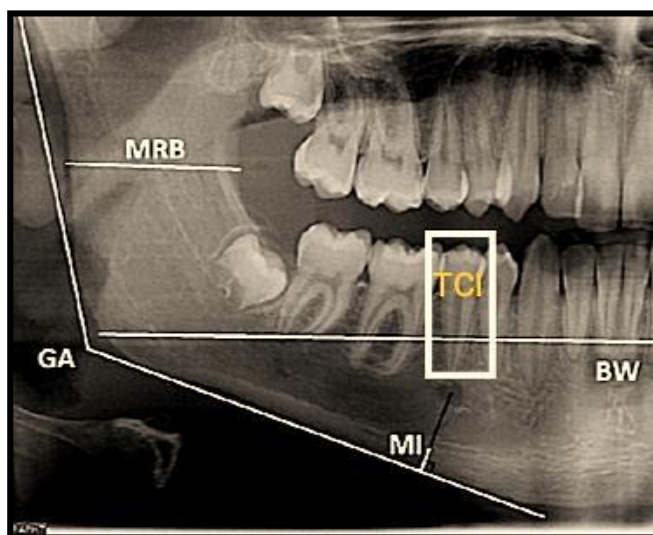


Fig 1. Antegonial Depth and Antegonial Angle with TCI of lower 2<sup>nd</sup> premolar