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Comparative Evaluation of Accuracy of Tooth Coronal Index and Pulp Tooth Ratio for Age Estimation in Adults- A Digital Panoramic Study

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Abstract

Background: Teeth are considered useful tools in age estimation because of their ability to resist various physical and chemical agents.

Aim and Objective: To estimate the age of individuals using the Tooth Coronal Index (TCI) and Pulp Chamber Crown Root Trunk Height Ratio (PCTHR) and to compare these methods with the chronological age for their accuracy.

Materials and Methods: Digital orthopantomographs of 300 subjects were selected based on the inclusion and exclusion criteria. Dental age estimation was performed by measuring TCI and PCTHR on the mandibular first molar using the Image J analysis software. The acquired data were subjected to Pearson's correlation test, unpaired t-test, and one-way ANOVA analysis.

Results and Observation: Statistically significant negative correlation was observed between the

chronological age and TCI (r=-0.284, *P*=0.009) and between the chronological age and PCTHR of the mandibular first molar (r=-0.336, *P*=0.005).

Conclusion: From the results of the study, PCTHR showed a slightly higher correlation than TCI, thus it was found to be a better tool than TCI for age estimation. Further clinical trials on different teeth are required to establish the accuracy of both methods for age determination in adults.

Keywords: Age estimation, Chronological age, Pulp Chamber Crown Root Trunk Height Ratio, Tooth Coronal Index.

Introduction

Aging is an unavoidable, inevitable process, beginning at conception till death. Within the field of forensic sciences, age determination in living individuals is a relatively new area of practical research. [1]

Although skeletal methods could be used for age prediction, several environmental factors influence bone maturation variability. [2] Moreover, dental tissues are more resistant to thermal, chemical, and mechanical stimuli. Therefore, teeth form a unique and suitable parameter for the estimation of dental age.[3]

In adults, age prediction must be done through analysis of root transparency, cementum annulations, and determination of aspartic acid racemization which frequently requires extraction that cannot be utilized for living persons.[4,5]

After root completion, secondary dentin is deposited throughout one's life reducing the dimensions of the pulpal cavity. Hence, it can be utilized as a predictor of age.[6] Tooth coronal index and pulp tooth ratio are based upon the relation between the age and dimensions of the pulpal cavity on dental X-rays.[7]

This study was undertaken to compare the precision of TCI and PCTHR in age determination using digital orthopantomographs in the adult population of Hyderabad.

Materials and Methods

About 300 digital orthopantomographs were obtained from the Department of Oral Medicine and Radiology. The sample size was determined by using G power software. The study complies with the principles of the Declaration of Helsinki, and written informed consent was obtained from all study subjects. [8] After acquiring institutional ethical committee clearance (Regd. No. ECR/300/Inst/AP/2013/RR-16), Tooth Coronal Index (TCI) and Pulp Chamber Crown Root Trunk Height Ratio (PCTHR) methods were performed on these digital orthopantomographs.

Inclusion criteria

- Good quality radiographs.
- Age between 18-70 years.
- Good morphology teeth.

Exclusion criteria

- Decayed, restored, missing, severely attrited, rotated, fractured, malaligned teeth.
- Patients with orthodontic appliances.
- History of bilateral extractions.
- Developmental anomalies.
- Periapical pathology.

Methodology

All 300 digital orthopantomographs [JPEG image format] were subjected to radiographic measurements in millimeters with the help of Image J analysis software [1.52g, Wayne Rasb and, (National Institute of Health, USA)].

Tooth Coronal Index (TCI)

For the left mandibular first molar, a straight line (cervical line) was traced at the cementoenamel junction, forming the division between the anatomical crown and root. The Coronal Height (CH) was traced vertically straight from the cervical line to the tip of the highest cusp according to Moss *et al*. [9] Coronal Pulp Cavity Height (CPCH) was measured vertically from the cervical line to the tip of the highest pulp horn according to Ikeda *et al*. [10] The resultant Tooth Coronal Index (TCI) was calculated as follows [Figure 1]:

TCI= CPCH X 100/CH

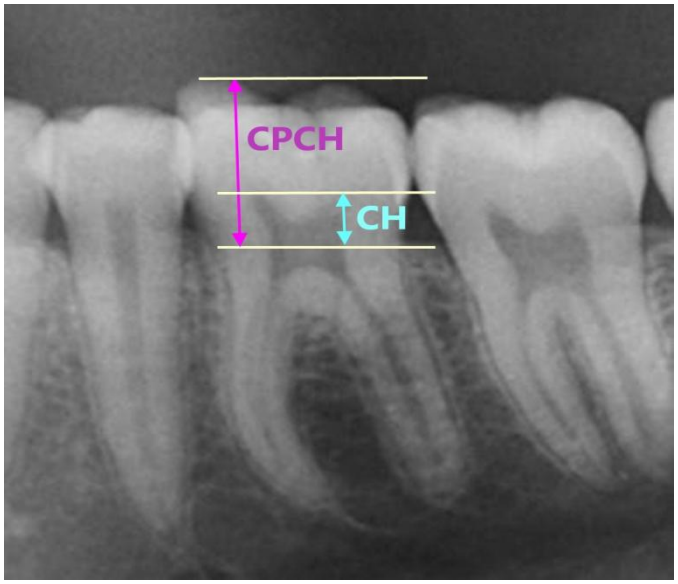

Figure 1: Digital Panoramic Image between the age group of 18-25 years showing measurements on the left mandibular first molar to calculate TCI.

Pulp Chamber Crown Root Trunk Height Ratio (PCTHR)

As proposed by Mathew *et al* [6], Crown Root Trunk Height (CRTH) was calculated as the distance between the central fossa and the highest point on the root furcation, and Pulp chamber Height (PCH) was calculated as the distance between the roof and floor of the pulp chamber. The resultant Pulp Chamber Crown Root Trunk Height Ratio (PCTHR) was calculated as [Figure 2]:

PCTHR= PCH/CRTH

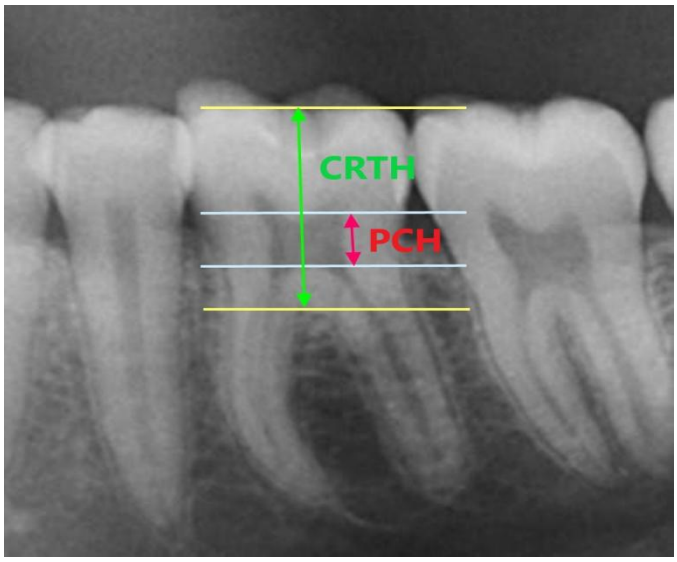

Figure 2: Digital Panoramic Image obtained between the age group of 18-25 years showing measurements on the left mandibular first molar to calculate PCTHR.

Statistical analysis

The obtained data were analyzed using SPSS for Windows 26.0 (IBM SPSS, Armonk, New York). Pearson's correlation analysis was performed to check the relationship between TCI, PCTHR, and CA. Unpaired t-test was performed to detect the correlation between the mean CA and mean estimated age by both TCI and PCTHR. One-way ANOVA test was performed to compare TCI and PCTHR with the CA.

Results

Digital orthopantomographs of 300 subjects were studied of which 163 were males and 137 were females between the age of 18-70 years. A linear negative correlation was noticed between TCI and CA (r=-0.284) with a correlation coefficient (R^2) of 0.0805 [Table 1]. Based on the test subsets, a regression equation was developed as follows using which age was estimated.

Estimated age = -0.439 (TCI) + 51.543

Unpaired t-test showed a negligible difference between the mean CA (39.8267) and mean calculated age (39.8254) with a *P*= 0.99, using TCI [Table 2]. A significant negative correlation was noticed between the PCTHR and CA (r=-0.336) and the correlation coefficient (R^2) value was 0.1128, respectively [Table 1]. Regression analysis gave the following equation using which the age was estimated.

Estimated age = -68.39 (PCTHR) + 54.53

Unpaired t-test showed an insignificant difference between the mean CA (39.8267) and the mean estimated age (39.8070) using PCTHR, with *P*= 0.982 [Table 2].

One-way ANOVA analysis showed no considerable difference between the calculated age by TCI and PCTHR from mean CA (*P*=1.0) [Table 3]. Among the 5 different age groups, 46-55 years showed a strong association between the calculated age and CA when compared to others. Regression analysis was also performed, which showed PCTHR as a better reliable indicator as the explained variance of CA is more with PCTHR than TCI [Table 4].

Discussion

Dental maturity plays a major role in estimating the chronological age of individuals due to the low variability of dental indicators.[11] It is particularly challenging to estimate age in adults than in younger age groups. Ritz and colleagues claim that after growth is complete, a variety of endogenous and exogenous factors, including illness, nutrition, and physical stress, influence alterations in the dentition.[12]

After root formation completes, the secondary dentin begins to deposit and it continues, decreasing the dimension of the pulpal cavity.[13] This deposition is principally linked with age advancement.[14] With advancing age, there will be continuous production of secondary dentin on the primary dentin's pulpal surface causing the pulpal cavity to narrow down. It is not deposited uniformly, i.e., in the molars, it is higher over the roof and the floor, leading to a decrease in the height rather than the width of the pulpal cavity.[15] The pulpal cavity can be measured by several methods such as tooth cross-sections and radiographs.[6]

Radiographic methods are non-destructive, reliable, and simple processes that are applicable to anyone in contrary to other time-consuming, expensive, less reliable, and destructive methods that may not be acceptable for ethical, cultural, scientific, or religious reasons whereas, procedures such as digitization of orthopantomographs and computer-aided image analysis improves the accuracy, reliability, and precision and reduces the observer subjectivity bias.[5]

Various studies were conducted to develop a formula for estimating age in Indian adults using radiography but these were not suitable in the older population due to loss of anterior teeth.[6] Conventional radiographic methods pose a number of problems such as processing errors, storage for a longer duration, image transfer, and measurements. [3] Recently, alternative approaches to the digitalization of orthopantomographs and their computerized storage have become available that allow non-destructive metric measurements of both pulp chambers and teeth, used to assess an individual's age. Forensic odontologists may now utilize these methods which are relatively precise and accurate. [15]

In the current study, digital orthopantomographs were utilized because of the likelihood of assessment of all teeth along with the alveolar bone in both jaws; several measurements can be performed on the same X-ray. The mandibular first molar had a well-defined pulp chamber. Pulpal morphometric values were evaluated using digital orthopantomographs.[5]

This is the first study comparing TCI and PCTHR for estimating age in the Hyderabad adult population. TCI correlated negatively with age (r=-0.284) which was in compliance with the study by Doni BR *et al* (r=-0.094) suggesting that as the CA advances, TCI decreases.[16]

Our results were consistent with the study by Jain S *et al* , where a negative correlation was noticed between CA and TCI (r=-0.921) and CA and PCTHR (r=-0.178), similar to our study (r=-0.284, r=-0.336). Also, PCTHR showed a slightly higher correlation than TCI, thus it proved to be a better indicator for the prediction of age than TCI.[7]

In this study, the mandibular first molar is mainly preferred for the measurements because the pulpal cavity is clearly visible and this is in compliance with the Veera *et al* study.[3] Moreover, the correlation between TCI and CA was negative (r=-0.284) which was comparatively greater than the correlation seen in Nagi R *et al* study (r=-0.0092).[2]

Our findings were in agreement with the study performed by Mehta S *et al* and Shah PH *et al* where there was an insignificant difference between the CA and the calculated age using PCTHR (*P*=1.0), similar to our current study, *P*= 0.989. Further, the method proposed by Mathew *et al* [6] for age prediction was confirmed on a greater sample and it was suggested that PCTHR could aid as a reliable tool in the prediction of age.[17,18]

Talabani RM *et al* found a correlation coefficient (R^2) of 0.49 implying a strong negative regression between CA and TCI. This observation agrees with our study (R^2=0.0805) and with the study conducted by Veera *et al.* [3,5]

Veera *et al* implied that the age-predicting potential of TCI declines as the age increases greater than 50 years, which might probably be because of various influences such as environment, and diet governing the anatomic and pathologic parameters affecting the pulp morphology. This was similar to our study, where we observed the least precision in the age group of 56-70 years using TCI.[3]

Conclusion

TCI and PCTHR can be reliable tools in estimating age in the Hyderabad population. CA showed a negative correlation with both methods in which PCTHR showed a slightly higher correlation than TCI, hence it is a more reliable method. Further studies on larger sample sizes, different teeth, and using modern radiographic methods like CBCT are necessary to determine the precision of both methods for the estimation of age in adults.

Limitations

- Small sample size
- Only the mandibular first molar tooth was used.

Future prospect

- Further studies should be carried out on larger samples, different populations, and in different geographical locations.
- Modern radiographic techniques like CBCT can be utilized to avoid any errors.

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Legend Tables

Table 1: Correlation between chronologic age and tooth coronal index (TCI) and between chronologic age and pulp chamber crown root trunk height (PCTHR) of mandibular first molar by using Pearson correlation coefficient test

		r value	R^2 value	P value
ChronologicalAge	TCI	-0.284	0.0805	0.009*
	PCTHR	-0.336	0.1128	0.005*

P value<0.05 - statistically significant

Table 2: Comparison between mean chronological age and mean estimated age using TCI and PCTHR by unpaired t-test

Methods	Mean chronological age	Mean estimated age	T value	P value
TCI	39.8267	39.8254	0.001	0.999
PCTHR	39.8267	39.8070	0.023	0.982

P value<0.05 - statistically significant

Table 3: Comparison between mean chronologic age and mean estimated age by tooth coronal index (TCI) and pulp chamber crown root trunk height (PCTHR) using one-way analysis of variance (ANOVA) test

Age	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
				LowerBound	UpperBound		
Chronological age	39.8267	14.12379	0.81544	38.2219	41.4314		
stimated age by TCI	39.8254	4.02633	0.23246	39.3680	40.2829		
Estimated age by PCTHR	39.8070	4.74615	0.27402	39.2677	40.3462	0.0001	1.0

P value<0.05 - statistically significant

Table 4: Unadjusted and adjusted explained variance by TCI and PCTHR.

Predictor	Unadjusted Explained Variance in CA	Adjusted Explained Variance in CA	P value
TCI	0.0795	0.0805	0.009*
PCTHR	0.1036	0.1128	0.005*