Original Article

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Dentistry Section

Comparative Evaluation of Age Estimation by Pulp Tooth Ratio with and without Grid: A Cross-sectional Study

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ABSTRACT

Introduction: Adult age estimation may be essential in post-mortem identification, and its significance is increasing in the field of forensics for both living and deceased persons. Using forensic odontology, one can accurately identify a person's race, age, and sex, as well as differentiate one group from another.

Aim: To estimate and compare dental age using the mandibular first molar by the Pulp Tooth Ratio (PTR), with and without a grid.

Materials and Methods: A cross-sectional study was conducted among subjects in Chidambaram, Tamil Nadu, India from January 2021 to December 2021. The study sample comprised 150 Orthopantamograph (OPGs). The tracing measurements were performed on the Joint Photographic Experts Group (JPEG) images using Adobe Acrobat 7.0 Professional software. A novel method, incorporating a grid in all the Orthopantomograms (OPG), was used to improve the accuracy of image tracing. The measurements were performed with and without the grid; the images were consistently zoomed to 160%, and the grid used was 0.1 cm × 0.1 cm. The tracing values were used to estimate age by the PTR. Statistical analysis was conducted using IBM Statistical Package for Social Sciences (SPSS) Statistics Version 20.0. An Unpaired T-test, Pearson's Correlation, and linear regression were performed.

Results: In the age-wise comparison between the two techniques, the mean dental age of the mandibular first molar using the PTR with and without the grid did not show statistical significance (p-value=0.951). The present study found no difference between the methods with and without the grid, showing highly correlated values using the PTR with and without the grid of -0.671 and -0.744, respectively. These r values are statistically significant (p-value <0.05), reflecting that the estimated age by both methods correlated with chronological age.

Conclusion: There was no statistical difference between the dental age estimated using the mandibular first molar by the PTR with and without the grid.

Keywords: Forensic dentistry, Odontometry, Radiography

INTRODUCTION

Age estimation has become increasingly important in the field of forensics to clarify legal queries related to employment, adoption, labour acts, as well as in cases involving individuals with criminal antecedents who are reluctant to reveal their age. It is also essential for verifying the age of immigrants and refugees with disputed birth records [1]. This relevance extends not only to routine casework but also to mass fatalities resulting from natural phenomena (e.g., tsunamis) and man-made catastrophes (e.g., terror attacks) [2].

Forensic odontology is a specialised field that combines dentistry and forensic medicine, as an in-depth knowledge of both areas is vital for its effectiveness. It is a well-known fact that tissues undergo continuous structural changes throughout life. The primary factors responsible for this ongoing process are environmental effects and aging [3]. The primary goal of forensic dentistry is to identify deceased individuals for whom other biometric identification clues-such as fingerprints and facial recognition- may not be available. Data collected from the morphology of the skull, jaws, odontometric analysis, palatal rugae patterns, and Deoxyribonucleic Acid (DNA) analysis of oral and paraoral tissues can play a significant role in identifying the gender and age of an individual [4].

Using forensic odontology, one can accurately identify a person's race, age, and sex, as well as differentiate one group from another [5]. Teeth were initially used as a barometer of age. Attrition of teeth, periodontal disease, and secondary dentin development are all noticeable changes that occur in teeth as they age. Teeth are suitable specimens for dental age assessment in cases where they are the only body components available for examination [3]. Tooth growth exhibits minimal variability concerning chronological age and less variability than other developmental parameters. Furthermore, compared to other tissues, dental tissues are less susceptible to endocrine disorders or dietary changes, and they are more resilient to mechanical, chemical, and thermal stresses. As a result, teeth provide a unique and appropriate criterion for estimating dental age [4].

Age estimation in adults falls into two categories: morphologic and radiologic techniques. Histological, biochemical, and clinical examinations are subcategories of morphologic approaches. Comparatively speaking, radiographic techniques are easier, non-destructive, and require less time and skill than morphologic techniques [6]. Recent advances in biochemistry have made it possible to estimate age with extreme precision. These methods, however, necessitate tooth extraction and typically involve tooth sectioning or processing, which may not be possible in living adults or, for that matter, in some jurisdictions that forbid the collection of tissue from human remains [2]. Since radiography is a non-invasive technique, it is essential in forensic dentistry to reveal information that cannot be seen through physical inspection. Radiographic techniques have been developed for studying the amount of secondary dentine deposited by measuring the pulp chamber size reduction [7]. Indeed, others have performed age estimation using the Pulp Tooth Ratio (PTR) in OPGs, as discrepancies in tracing values can occur from individual to individual. In this regard, a novel method involves incorporating a grid in all the OPGs to minimise human observational error and to improve the accuracy of image tracing. The aim of the study was to estimate and compare dental age using the mandibular first molar by PTR with and without the grid.

MATERIALS AND METHODS

A cross-sectional study was conducted among subjects in Chidambaram, Tamil Nadu, India, aged 20 to 49 years, using images of panoramic radiographs from January 2021 to December 2021 to estimate and compare the dental age of the mandibular first molar using the PTR with and without a grid. Ethical clearance was obtained from the Institutional Human Ethical Committee of Rajah Muthiah Medical College and Hospital (IHEC/698/2021).

Inclusion and Exclusion criteria: The inclusion criteria for the study included OPGs from subjects aged 20 to 49 years. One of the mandibular first molars should be present with ideal tooth and crown morphology, and the image quality should be good without any distortion. Digital panoramic radiographs that showed image distortion, mandibular lesions in the selected teeth, selected teeth with carious or periapical pathology, root stumps, prostheses, restorations, severe attrition or fractures, rotated, drifted, or malaligned teeth and any developmental anomalies were excluded from the study.

Sample size calculation: The sample size was calculated using statistical power analysis with G*Power 3.1 software, and the total sample size for the current study was estimated to be 150 OPGs [8]. The collected OPG images were divided into three groups based on age. Each group comprised 50 OPGs, where Group-1 consisted of individuals aged 20-29 years, Group-2 consisted of individuals aged 30-39 years, and Group-3 consisted of individuals aged 40-49 years.

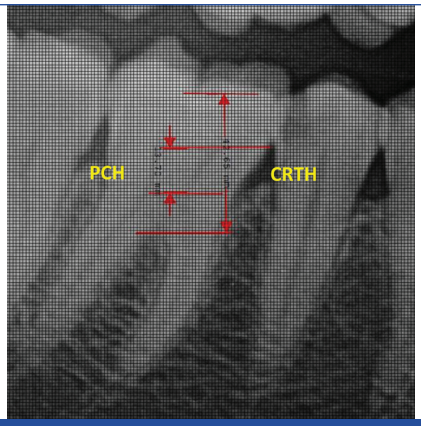
Radiographic images were collected from a private scan centre. The tracing measurements were performed on the JPEG images using Adobe Acrobat 7.0 Professional software. A novel method involving a grid was incorporated into all the OPGs to improve the accuracy of the image tracing. The measurements were performed both with and without the grid on all 150 OPGs. The images were consistently zoomed to 160%, and the grid used was 0.1 cm x 0.1 cm. The tracing values were then used to estimate age using the PTR by a blinded investigator.

Measurement of Pulp Tooth Ratio (PTR)

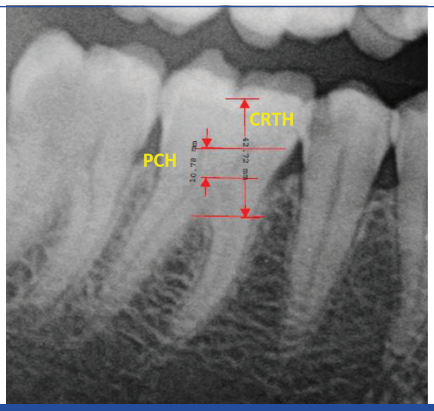
In the JPEG image of the OPG, the tracing points were marked precisely with the help of the grid. The measurements and dental age estimation were performed according to the method described by Mathew DG et al., [7]. The measurements were taken on the mandibular right first molar; if it was absent, measurements were taken on the mandibular left first molar. The Crown Root Trunk Height (CRTH) was calculated as the distance between the lowest point of the central fossa of the crown and the highest point of the root furcation of the molar. The Pulp Chamber Height (PCH) was calculated as the distance between the roof and floor of the pulp chamber along the same axis, in millimeters (mm) [Table/Fig-1]. Similar measurements were repeated without the grid on the same OPG [Table/Fig-2]. A ratio of PCH to CRTH was derived as the Pulp Chamber Crown Root Trunk Height Ratio (PCTHR), calculated as follows: PCTHR=PCH/CRTH. In the present study, the mean estimated age using the PTR technique was correlated with the chronological age of the subjects [9].

STATISTICAL ANALYSIS

Data regarding chronological age and dental age estimated using the PTR, both with and without a grid, were entered into Microsoft Excel and analysed using IBM Statistical Package for Social Sciences (SPSS) Statistics for Windows, Version 20 (IBM Corp., Armonk, N.Y., USA). The data were investigated for normality using the Kolmogorov-Smirnov test. Descriptive statistics were derived. The dental age of the mandibular first molar, measured with and without a grid using PTR, was analysed using an unpaired t-test. Pearson's correlation and linear regression were performed between chronological age and dental age estimates using different techniques. The level of statistical significance was determined at p-value <0.05.



[Table/Fig-1]: Measurements using Pulp Tooth Ratio (PTR) with grid.



[Table/Fig-2]: Measurements using Pulp Tooth Ratio (PTR) without grid.

RESULTS

A total of 150 OPGs were collected based on selection criteria. The overall mean dental age estimated using the PTR, with and without the grid, was 35.33±8.713 and 35.39±8.141, respectively [Table/Fig-3].

Method employed to estimate dental age	n (150)	Minimum	Maximum	Mean	Standard deviation
Pulp Tooth Ratio (PTR) with grid	150	16	56	35.33	8.713
Pulp Tooth Ratio (PTR) without grid	150	15	54	35.39	8.141

[Table/Fig-3]: Descriptive statistics of the samples based on the method used to estimate the dental age of the population.

It was observed in the study that the estimated mean dental age using PTR, both with and without a grid, for individuals aged 20 to 29 years (Group 1) was 29±7.33 and 28.70±6.30; for those aged 30 to 39 years (Group 2), it was 33.72±4.61 and 34±3.89; and for individuals aged 40 to 49 years (Group 3), it was 43.28±6.91 and 43.48±5.67, respectively [Table/Fig-4].

Method employed to estimate dental age	Age groups (years)	n (150)	Mean	Standard deviation
PTR with grid	**Group 1-** 20-29	50	29.00	7.332
	Group 2- 30-39	50	33.72	4.616
	Group 3- 40-49	50	43.28	6.911
	Total	150	35.33	8.713
PTR without grid	**Group 1-** 20-29	50	28.70	6.303
	Group 2- 30-39	50	34.00	3.897
	Group 3- 40-49	50	43.48	5.676
	Total	150	35.39	8.141

[Table/Fig-4]: Descriptive statistics of the samples based on the chronological age grouping of the participants.
PTR: Pulp tooth ratio

The mean dental age of mandibular first molar using PTR with grid was estimated to be 35.33+8.713 and without grid it was found to be 35.39+8.141. The mean difference between these groups is found to be -0.060 and it was statistically not significant (p-value=0.951) this reflects that there was no statistical difference between the dental age estimated by both the methods [Table/Fig-5].

Groups	n	Mean ±SD	95% Confidence interval of the mean		Mean difference	df	Unpaired t-test value	p-value
			Lower	Upper				
Pulp Tooth Ratio (PTR) with grid	150	35.33+ 8.713	26.617	44.043	-0.060	296.638	-0.062	0.951
Pulp Tooth Ratio (PTR) without grid	150	35.39+ 8.141	27.249	43.531				

[Table/Fig-5]: Comparison of the dental age of mandibular first molar, with grid and without grid by Pulp Tooth Ratio (PTR).
*Statistically Significant (p<0.05)

A negative correlation was found when comparing chronological age to estimated dental age using PTR with and without the grid, with correlation coefficients of -0.671 and -0.744, respectively. These r values were found to be statistically significant (p-value <0.05), indicating that the estimated age from both methods correlates with chronological age [Table/Fig-6].

Chronological age grouping	Pulp Tooth Ratio (PTR) with grid	Pulp Tooth Ratio (PTR) without grid
Pearson Correlation (r)	-0.671	-0.744
p value	<0.001*	<0.001*

[Table/Fig-6]: Correlation between chronological age with dental age estimates using different techniques (Pearson Correlation).
*Correlation is statistically significant at the 0.05 level

For every unit (one year of age) decrease in dental age estimation, using the PTR with and without a grid, there is an expected average increase of 0.063 and 0.075 in chronological age, respectively [Table/Fig-7].

Coefficients[a]						
Model 1	R square	Beta coefficient	t-value	Sig.	Lower bound	Upper bound
Pulp Tooth Ratio (PTR) with grid	0.451	0.063	11.020	0.000*	0.052	0.072
Pulp Tooth Ratio (PTR) without grid	0.553	0.075	13.531	0.000*	0.064	0.086

[Table/Fig-7]: Linear regression between chronological age and different techniques used to estimate dental age.
a. Dependent Variable: Chronological Age grouping

DISCUSSION

The dental age determined by the pulp-tooth ratio for the mandibular first molar, using both the grid and without grid techniques, was significantly correlated with chronological age. However, when comparing the groups (with and without grid), the pulp-tooth ratios of the mandibular first molar did not show statistical significance, indicating that the use of a grid does not affect the study outcome.

Since, the environment has little effect on teeth, they are considered a trustworthy body part for forensic age estimation [1]. The age of human remains can be estimated using a variety of anatomical structures. Nonetheless, teeth have the advantage of being more resistant to effects that alter tissue both before and after death. Radiographs, which use low radiation exposure, and clinical examinations of teeth can be utilised to estimate the age of living individuals.

The morphological characteristics of teeth on radiographs are believed to provide a more accurate method for age estimation than most other techniques. According to previous studies, the apposition of secondary dentin causes the size of the dental pulp to decrease with age [10,11]. For this reason, secondary dentin apposition is considered the most accurate method of determining age, particularly beyond the age of 25. The calcified non-tubular material that the pulp deposits on the walls of the pulp chamber and root canal is known as "secondary dentin," and it persists throughout life. The pulpal cavity shrinks with age as normal secondary dentin is deposited on the pulpal surface of the primary dentin. Reports indicate that this secondary dentin apposition is not uniform across the pulpal cavity; in the case of molars, it occurs more over the floor and roof, reducing the height of the pulpal chamber rather than its width [2,11,12].

Using radiological and histological techniques, cross sections of teeth can quantify the loss of secondary dentin apposition, which serves as a marker of aging. We employed panoramic radiographs in the present study due to their high digitalisation and reproducibility. Additionally, radiographic methods require no extraction, involve less time, can be used on both living and deceased individuals, and do not necessitate specialist equipment. Digital panoramic radiography has been utilised in several studies in the literature to determine age [6].

In a study similar to the present one, Mathew DG et al., established a method for estimating age in South Indian individuals by measuring the height of the pulp chamber and the crown-root trunk of the mandibular first molar. They found a strong negative correlation between the PTR and chronological age (r-value=-0.56, p-value=0.000) [7]. Jain S et al., in his study, aimed to evaluate the reliability and accuracy of dental age assessment through two different methods utilising digital panoramic radiographs. A negative linear correlation was observed between the pulp height (PTH) and the chronological age of the mandibular first molar (r-value=-0.921), and the results were consistent with the present study [9].

In the present study, for every unit decrease in dental age estimation using the pulp-tooth ratio with and without grid, there can be an average expected increase in chronological age. The current study's results were consistent with the study by Shah PH and Venkatesh R which indicated that the pulp-tooth ratio of the mandibular first molar decreased with increasing individual age [13].

The overall mean dental age of the mandibular first molar, when comparing the pulp-tooth ratio with the grid and without the grid, was found to be not statistically significant, indicating that both techniques yield a similar dental age. In the age-wise comparison, the mean dental age of the mandibular first molar using the pulp-tooth ratio with and without the grid shows statistical significance, reflecting that the estimated dental age of both techniques correlates with chronological age.

From the present study, no difference was found when using the grid versus without the grid, demonstrating a highly correlated value and beta coefficient value. This suggests that incorporating the grid into the technique to increase the accuracy of tracing the morphological pattern does not provide any advantage.

Recently, Cone-Beam Computed Tomography (CBCT), a three-dimensional imaging technique (3D), provides valuable 3D information about teeth, enabling more accurate measurement of tooth and pulp dimensions compared to 2D radiography [14].

Limitation(s)

A range of environmental, racial, nutritional, genetic, and cultural factors should be taken into account in future studies on different teeth, in various groups, and in different locations. In future studies,

instead of using age from OPG films, the chronological age recorded from the day of birth can provide accurate data for reliable results. Studies can be conducted using three-dimensional imaging to improve the accuracy of dental age estimation.

CONCLUSION(S)

The PTR is a simple, effortless approach that allows for the quick analysis of more radiographs and serves as a cost-effective means to estimate age through morphometric analysis of the pulpal cavity's shrinkage with age. From the results of this study, concluded that chronological age has a negative correlation with PTR. There was not much difference between using a grid and not using one; both methods showed negative correlation values and beta coefficient values. This reflects that incorporating a grid into these techniques to increase the accuracy of tracing the morphological pattern does not offer any advantages.

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