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Estimation Of Chronological Age Using Pulp Chamber Crown Root Trunk Height Ratio In Orthopantomography: A Retrospective Study Of 200 Subjects

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Abstract
Background: *Age estimation plays a crucial role in forensic identification and is also valuable in archaeological and anthropological research. Various methods exist for age estimation, among which dental radiography has gained prominence due to its reliability and non-invasive nature. The pulp chamber crown root trunk height ratio (PCTHR) is an emerging method for age estimation using Orthopantomography (OPG).*
Objective: *This study aims to establish a relationship between chronological age and PCTHR and to derive a regression model for accurate age estimation based on this relationship.*
Materials and Methods: *A total of 200 OPGs were retrospectively analyzed, focusing on the mandibular first molar. The study included subjects aged 18 to 72 years, excluding teeth with pathologies or prior dental treatment. Measurements were taken using KDIS Dicon software, calculating the PCTHR for each subject. A regression model was developed using Pearson correlation and applied to test the subset to validate the accuracy of age prediction.*
Results: *The study found a statistically significant negative correlation between chronological age and PCTHR ($r = -0.476$; $P = 0.000$). The regression equation derived was: Estimated age = -155.782(PCTHR) + 61.722. The model was validated on a test subset, showing no significant difference between actual and estimated ages.*
Conclusion: *PCTHR is a reliable marker for age estimation in forensic contexts. The regression model provides a practical tool for age estimation in adults using OPGs.*
Keywords:- *Age estimation, pulp chamber height, Orthopantomography, dental radiography, regression analysis.*

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I. Introduction

Age estimation is an integral component of forensic science, particularly in cases involving unidentified human remains, criminal investigations, and disaster victim identification. It also holds importance in civil cases, such as determining the age of undocumented individuals. Various biological markers have been utilized for age estimation, among which dental structures are considered highly reliable due to their resistance to post-mortem changes. Dental age estimation methods have evolved over time, with radiographic techniques providing non-invasive and repeatable results.

Orthopantomography (OPG), also known as panoramic radiography, is widely used in dental practice for diagnostic and forensic purposes. It provides a comprehensive view of the maxillofacial region, allowing for the evaluation of teeth, bones, and other structures. OPG has been instrumental in various age estimation methods, particularly those focusing on tooth development and mineralization.

The pulp chamber crown root trunk height ratio (PCTHR) is a novel metric that has gained attention for its potential in age estimation. The pulp chamber undergoes changes over time due to secondary dentin deposition, leading to a reduction in its size. This reduction is correlated with chronological age, making

PCTHR a valuable parameter for age estimation. Previous studies have demonstrated the utility of PCTHR in forensic age estimation, with promising results.

This study aims to explore the relationship between PCTHR and chronological age using OPGs and to develop a regression model that can accurately estimate age based on this relationship.

II. Materials And Methods

Study Design and Sample Collection:

This retrospective study was conducted on 200 OPGs obtained from subjects who reported to the Dental Wing of G.G.S. Medical College and Hospital, Faridkot. The OPGs were collected as part of routine dental treatment, ensuring the subjects had provided informed consent for the use of their radiographs in research. The Institutional Ethical Committee approved the study protocol.

Inclusion and Exclusion Criteria:

The inclusion criteria for the study were:

1. Subjects aged between 18 and 72 years.
2. Fully erupted mandibular right first molar.
3. Fully formed root of the mandibular right first molar.

The exclusion criteria were:

1. Root canal-treated teeth.
2. Impacted teeth.
3. Teeth with visible periapical pathologies, caries, or attrition.
4. Teeth with radio-opaque fillings or crowns.

Radiographic Analysis:

Digital panoramic images of the mandible were obtained using the Kodak 8000C Digital Panoramic and Cephalometric System. The OPGs were analyzed using KDIS Dicon software, which was employed to mark points and record measurements accurately.

Measurement Protocol:

In each OPG, a mandibular first molar was randomly selected. The following measurements were recorded:

1. **Crown Root Trunk Height (CRTH):** The distance between the central fossa and the highest point on the root furcation.
2. **Pulp Chamber Height (PCH):** The distance between points on the roof and floor of the pulp chamber bisecting the CRTH line.

The PCTHR was calculated using the formula:

PCTHR (Pulp Chamber Crown Root Trunk Height Ratio) = -0.001 (Age) + 0.221

Statistical Analysis:

Data were analyzed using SPSS (Statistical Package for the Social Sciences) version 11.5. The study sample was divided into two subsets: the study subset (n = 100) and the test subset (n = 100). The study subset was used to derive the regression formula, while the test subset validated the accuracy of the formula.

Pearson correlation was performed to evaluate the relationship between chronological age and PCTHR. Regression analysis was conducted on the study subset to develop a linear regression equation for age estimation. The regression model's adequacy was assessed using the coefficient of determination (R^2), and reliability was evaluated using the split-half method.

Validation:

The derived regression equation was applied to the test subset to predict the age. The difference between the actual chronological age and the estimated age was recorded as the error. An independent samples t-test was used to compare the chronological age and estimated age in the test subset. Mean Absolute Error (MAE) was calculated, and the percentage of cases with the estimated age within ± MAE and within ±10 years was determined. Intra-observer reliability was assessed using the intra-class correlation coefficient. A P-value of less than 0.05 was considered statistically significant.

III. Results

Orthopantomography (OPG) of 200 subjects was used for the study. The distribution of subjects by age and gender is shown in Table 1.

Table 1: Distribution of Subjects by Age and Gender

Age Group (Years)	Male	Female	Total
10-19	6	12	18
20-29	41	21	62
30-39	19	27	46
40-49	15	22	37
50-59	18	6	24
60-69	5	6	11
70-79	2	-	2
Total	106	94	200

Correlation and Regression Analysis:

A statistically significant negative correlation was found between chronological age and PCTHR (r = -0.476, P = 0.000). Regression analysis on the study subset produced the following linear regression equation for estimating age:

Estimated Age = −155.782 (PCTHR) + 61.722. (PCTHR is the pulp chamber crown root trunk height ratio).

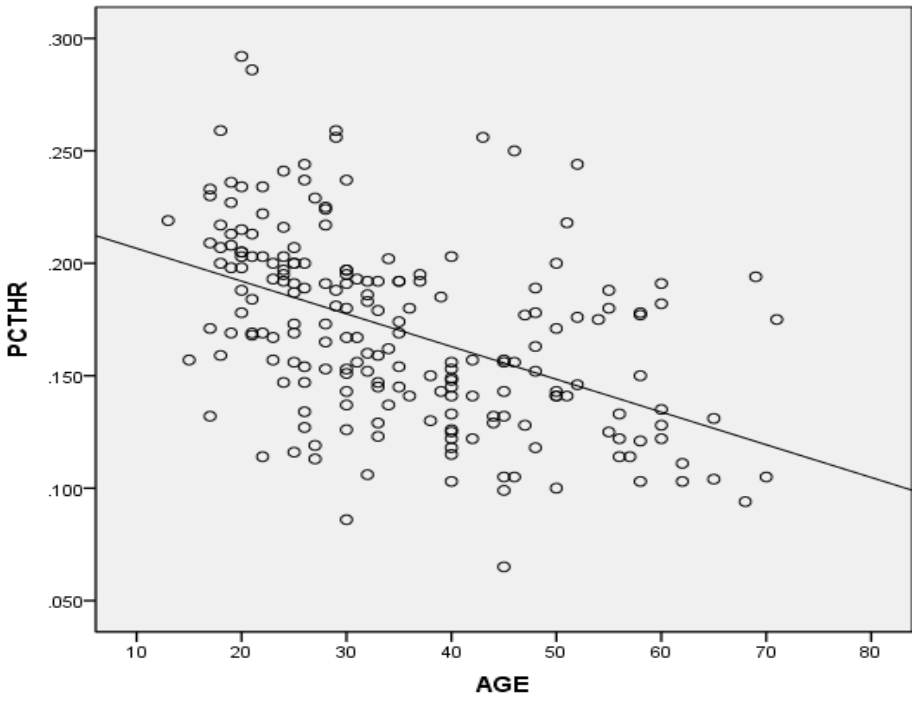

Figure 1

The scatter plot distribution of PCTHR against chronological age is shown in Figure 1.

The regression equation was applied to the test subset, and the predicted ages were compared with actual ages. The R-value for the regression equation was 0.476, indicating a moderate correlation. The Mean Absolute Error (MAE) between the actual and estimated ages was found to be 4.5 years. The percentage of cases with the calculated age within ± MAE was 85%, and within ±10 years was 95%. No significant difference was found between the actual and estimated ages (P > 0.05).

Intra-observer Reliability:

The intra-class correlation coefficient for intra-observer reliability was 0.88, indicating high reliability in measurements.

IV. Discussion

The study aimed to establish the relationship between PCTHR and chronological age and to develop a regression model for accurate age estimation. The findings indicate a significant negative correlation between

chronological age and PCTHR, consistent with previous studies that have explored similar relationships using dental radiographs.

The regression equation derived in this study provides a practical tool for estimating chronological age based on PCTHR. The accuracy of the model, validated on a test subset, suggests that PCTHR can be reliably used in forensic age estimation. The Mean Absolute Error of 4.5 years falls within an acceptable range for forensic applications, particularly when considering the variability inherent in biological age markers.

Previous studies have employed various methods for dental age estimation, including the Tooth Coronal Index (TCI), Gustafson's method, and Kvaal's method. The PCTHR method presents several advantages, including its non-invasive nature, ease of application, and reproducibility. Unlike other methods that rely on subjective assessments, PCTHR can be objectively measured using digital software, reducing potential biases.

However, the study has certain limitations. The sample size, although adequate, may not fully represent the population's diversity. Additionally, the study focused solely on the mandibular first molar, which may limit the generalizability of the findings to other teeth. Future research should explore the applicability of PCTHR across different teeth and populations.

The moderate correlation observed in this study ($r = -0.476$) suggests that while PCTHR is a useful indicator, it may need to be combined with other dental and skeletal markers for more accurate age estimation. Integrating PCTHR with other established methods could enhance the precision and reliability of forensic age estimation.

V. Conclusion

The Pulp Chamber Crown Root Trunk Height Ratio (PCTHR) is a promising metric for estimating chronological age using Orthopantomography. The significant correlation between PCTHR and age, coupled with the regression model developed in this study, offers a reliable method for age estimation in forensic and clinical settings. Further studies with larger and more diverse populations are recommended to refine the model and explore its applicability across different demographics.

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