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ORIGINAL ARTICLE

A Retrospective Analysis of Age Assessment using Visual and Radiological Methods in South Indian Population

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Abstract:

Teeth are one of the most important biological indicators of ageing due to their high mineral content and resistance to change after death. Dental maturity indicates biological age for criminal, forensic, and anthropological purposes. When no information is known about the deceased, forensic human identification requires age estimation. This study used Lamendin's and Kvaal methods to evaluate and construct a regression model for dental age assessment in extracted single-rooted mandibular premolar teeth in south Indian population. Mandibular extracted first premolars were obtained from the patient from 15 to 75 years old. The patient details were blinded before analysis. The root height, root translucency, and periodontosis parameters were measured using Lamendin et al's technique. Based on the method proposed by Kvaal et al the morphological measurements of the teeth were calculated with six measurements for each tooth. In the results to determine the mean and standard deviation, descriptive statistics were used, and unpaired t-tests /Pearson correlation were used to compare age to other parameters and P-value <0.05 indicated as significant. South Indian population had a greater standard error of estimated age using Lamendin et al. and Kvaal's approach. Then modified Lamendin's and Kvaal's formula was used to South Indians and yielded accurate findings. This study concludes that the formula which was derived from the French population(Lamendin's) and the Norwegian population(kvaal's) does not apply to the South Indian population.

Keywords: Age estimation; Forensic sciences; Mandibular premolars; Lamendin’s method; Kvaal's method.

Introduction:

The tooth is an extremely valuable biological indicator of age due to its mineralized composition and ability to withstand alterations after death. Dental maturity status is a dependable indicator of biological age, especially in the domains of forensic research, criminal investigations, and anthropology. Age assessment is vital in forensic human identification, especially in circumstances when there is a lack of information regarding the deceased person.[1]

Several factors, including genetics, race, diet, temperature, hormones, and environment, might potentially impact an individual's growth. Therefore, it is essential to assess age estimation techniques in a particular group utilising basic tools such as optical methods and digital imaging.[2,3] Dental radiographs, including intraoral periapical, bitewing, and orthopantomography, or a combination of radiographs involving the third molar tooth, hand, wrist, and cervical vertebrae, can be utilised to accurately calculate age until the onset of puberty.[4] However, precisely calculating age becomes difficult once the third molar has emerged, and the only things that assist in this procedure are the normal ageing process and regressive changes.

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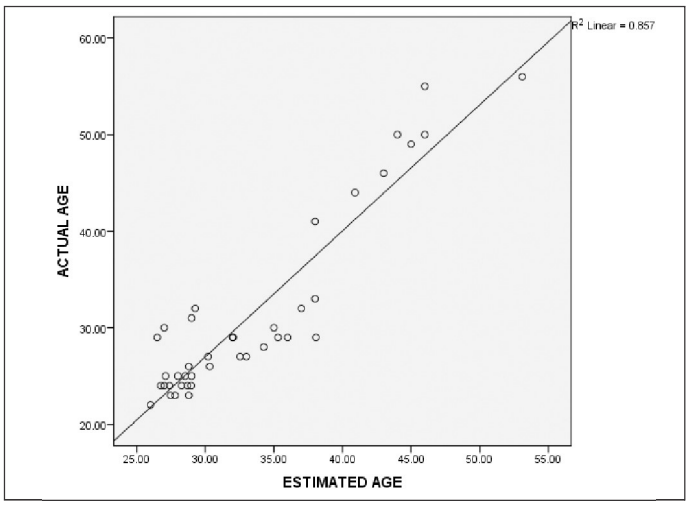
Age estimates based on root translucency are typically dependable for those who are 30 years old and older, providing a benefit compared to other measures of skeletal ageing that lose accuracy for those who are 50 years old and older.[5,6] Lamendin et al. performed a comprehensive evaluation of the patient's health by analysing the transparency of the tooth roots, the extent of periodonal retraction, and the length of the roots on both the labial and lingual sides of the teeth.[7,8]

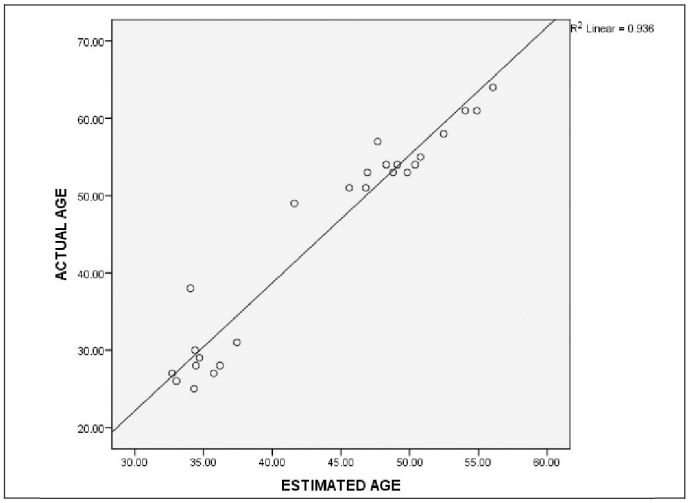
This approach is distinguished by its simplicity and lack of intricate equipment demands, rendering it highly versatile. Most studies have retrospectively utilised extracted teeth to determine an individual's age using this approach. Only a small number of recent studies have employed this technique on patients who have undergone panoramic radiographs, CBCT, digital intraoral radiography, and traditional intraoral radiographs (either alone or in a combination of maxillary and mandibular teeth). These investigations have yielded statistically significant evidence indicating a link between the actual age and the estimated age.[9] Insufficient research has been conducted to compare these two strategies for dental age evaluation. Thus, this study aimed to ascertain the chronological age and devise a new regression model for calculating dental age in extracted single-rooted mandibular premolar teeth. This would be achieved by employing Lamendin's technique and Kvaal's method in a population from South India.

Methods:

A retrospective study was conducted in our institution's Department of Oral Medicine and Radiology. A total of 65



Graph 1. Comparison of actual and chronological age in original formula.



Graph 2. Comparison of actual and chronological age in newly derived formula.

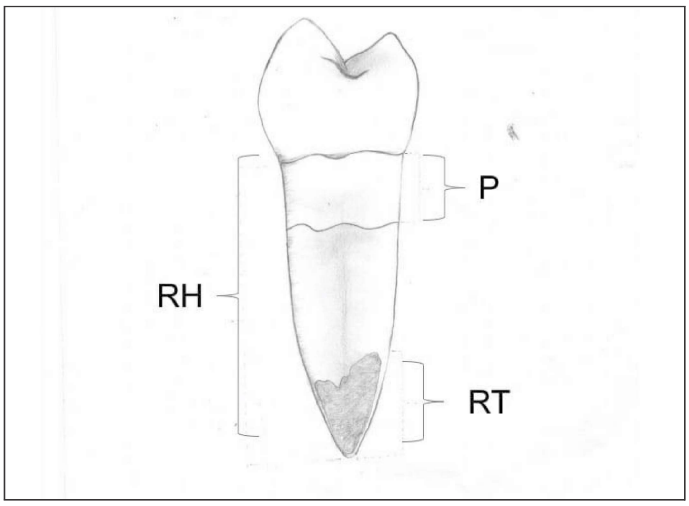


Figure 1. Schematic representation.

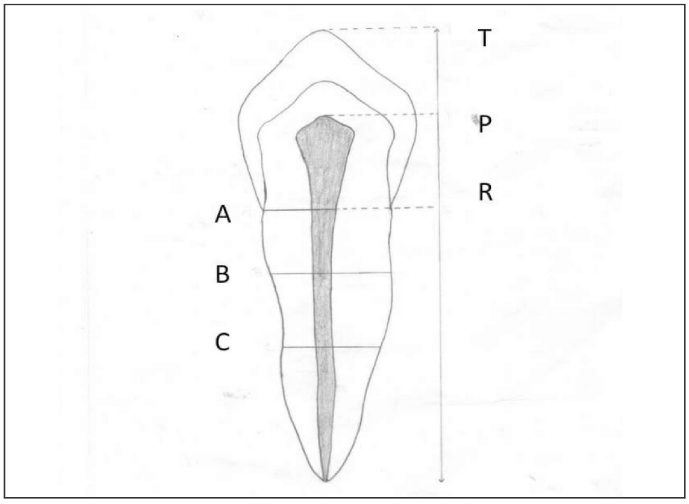


Figure 2. Schematic representation.
Tooth length/root length (T), pulp length/root length (P), pulp length/tooth length (R), pulp width/root width at level "a" (A), pulp width/root width at level "b"(B), pulp width/root width at level "c"(C).

mandibular premolars with a single root were randomly selected for analysis. Inclusion criteria encompassed individuals aged 18 to 75 years with documented date of birth, who had undergone tooth extraction for periodontal issues, orthodontic reasons, or any other cause.

Clinically absence of any developmental, endocrine, or nutritional problems that may impair tooth development, was considered. Exclusion criteria were teeth that had undergone restoration, had fractures, decay, or root resorption. The chronological age was calculated using Microsoft Excel by subtracting the date of birth from the date of tooth extraction. After sample collection, observers were blinded to patient data. All measurements were taken twice over 15 days by the same observer to reduce intra-observer bias. All the measurements were obtained to the millimeter. To test repeatability and reproducibility, 25 teeth were randomly selected from 65 teeth and all variables were re-measured by the observers.

Techniques: Lamendin's technique[10]: The data collection was done by using a visual technique where three measurements, namely Root height, Periodontosis, and Root translucency, were taken using a digital vernier calliper with a precision of 0.01 mm. The evaluation focused on the height of the root and the presence of periodontosis on the labial surfaces. Translucency of the root was assessed on the proximal surface of every premolar. The root height was measured as the distance from the tip of the root to the cementoenamel junction of the premolars. The periodontal height (periodontosis) was determined by measuring the greatest distance between the cemento-enamel junction and the line formed by the attachment of soft tissue on the neck and/or root of a tooth. The observation of root transparency involved examining the tooth under a strong light source in a darkened space and measuring the distance from the root apex to the highest point of visible transparency within the root [Figure-1]. The age was estimated using the following formula:

$$Age = (0.18 \times P) + (0.42 \times T) + 25.53,$$

where P and T are: P = (measured periodontal recession height × 100)/measured root height

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T = (measured root transparency height × 100)/measured root height

Kvaals Technique[11]: This is a radiographic technique, the analysis of the images was conducted using GIMP V 2.10 software, following the methodology described by Kvaal et al. The morphological measurements of the teeth were determined by calculating six measurements for each tooth, starting from the mesial aspect. Radiographs were taken using the Acteon X-mind DC X-ray machine with radiovisiography [Figure-2].

The additional analysis was performed by importing the quantitative data into Office Excel® 2007 (Microsoft®, Redmond, Washington, US). To calculate the age, the measured parameters were fed into Lamendin's formula and kvaals formula, a new regression formula was developed.

The obtained values were applied to the formula developed to estimate the age from mandibular premolars given by Kvaal's et al.

Age=133.0-318.3(M)-65.0(W-L)

W = Mean value of width ratios from level B and C

L = Mean value of length ratios P and R

W − L = Differences between W and L

Modified Kvaal's formula was made utilizing the ratios obtained from data sets

Age=123.22-141.2(M)-16.12(W-L)

Data analysis: Statistical analysis was done by using SPSS (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp. Released 2019). Descriptive statistics was done to assess the mean and standard deviation and to assess the gender difference unpaired t test was used and Pearson correlation was done between actual age and other parameters included in the study. P-value <0.05 was considered statistically significant.

Results:

Table 1: Pearson correlation between actual age and parameters in the study.

Parameters	Correlation coefficient	P-value
Root height	0.023	0.281
Periodontosis	0.532	0.013*
Root translucency	0.824	<0.01*
P	0.494	<0.01*
T	0.948	<0.01*
Estimated age	0.274	<0.01*

Table 2: Comparison of estimated and chronological age.

Variables	Lamendin formula		Newly derived formula		P-value
	Chronological age	Estimated age	Chronological age	Estimated age	
Mean	31.2250	33.2523	44.6800	43.6096	
Std. Error of Mean	1.51678	1.07562	2.74452	1.60290	
Std. Deviation	9.59297	6.80279	13.72261	8.01449	0.017*
Variance	92.025	46.278	188.310	64.232	
Range	34.00	27.10	39.00	23.33	
Minimum	22.00	26.00	25.00	32.72	
Maximum	56.00	53.10	64.00	56.05	
P-value	0.092		0.097		

A significant correlation was seen between age and age-related indicators such as root transparency (r = 0.824, P < 0.001) and periodontosis (r = 0.532, P < 0.001). Nevertheless, there was no significant link observed between root length and age. [Table-1]. The mean age of the entire sample was 44.75 years with a standard deviation of 10.52. Lamendin's formula overestimated the chronological age of the research sample. Furthermore, a majority of the overestimated individuals were above the age of 40, The mean differences in Chronological age and estimated age between the age categories were statistically significant [Table-2]. A significant disparity was apparent within the age range of 50 to 65 years. Nevertheless, there was no notable disparity between genders in the measured and estimated values. Consequently, the regression equations were developed to estimate the age based on the root translucency and periodontosis characteristics for overall samples. The regression equation based on the data of the mandibular premolars is as follows: Age= (0.21 × P) + (0.49 × T) + 32.74. This equation was tested on a sample of 25 randomly selected mandibular premolars. The standard error estimation of ±5.5 Years in the modified lamendin's formula [Table 2].

Kvaal's technique revealed a significant correlation between chronological age and estimated age by using the parameters mentioned in the methodology [Table 3] with a P value < 0.01. The standard error of estimated age was (±11.5 years). The accuracy of the method for calculating age was assessed by comparing the estimated age to the recorded chronological age. When compared to the findings they obtained with the Norwegian population, it was discovered that the Kvaal's formula gave less accurate results in our population.

Based on the available data set modified Kvaal's formula for our population was derived.

Age=123.22-141.2(M)-16.12(W-L)

Modified kvaal's formula was tested in randomly selected 25 subjects and the same ratios were calculated and applied to the modified Kvaal's formula and age estimation was done. Standard error of estimated age by modified Kvaal's formula (±6.4 years).

The modified formula for both methods showed a significant reduction in standard error estimation of ±5.5 Years in the

Table 3. Correlation coefficients between chronological age and ratios of measurements from dental radiographs and mean of the ratios from mandibular premolars.

Measurments	r-value
T	-0.21*
P	-0.365*
R	-0.112*
A	-0.499*
B	-0.630*
C	-0.585*
M	-0.681*
W	-0.523*
L	-0.309*
W-L	-0.516*

P value: Level of significance <0.01 r: Correlation coefficient; B: Pulp and tooth width ratio at the midpoint between enamel cementum junction and mid root level; C: Pulp and root width ratio at the mid root level; W: Mean value of width ratios from level B and C; A: Pulp and root width at the enamel cement junction; P: Pulp length/root length; R: Pulp length/tooth length; L: Mean value of length ratios P and R; M: Mean value of all the ratios excluding T; T: Total length.

Table 4. See comparison between lamendin's and kvaal's formula in south indian population and modified lamendin's and kvaal's formula.

Formula	SEE (years) in comparison with chronological age
Lamendin's formula Age = (0.18 × P) + (0.42 × T) +25.53	±10.5 Years
Modified Lamendin's formula Age= (0.21 × P) + (0.49 × T) + 32.74	±5.5 Years
Kvaal's formula Age=133.0-318.3(M)-65.0(W-L)	±11.5 Years
Modified Kvaal's formula Age=123.22-141.2(M)-16.12(W-L)	±6.4Years

modified lamendin's formula and ±6.4 years in the modified kvaal's formula when compared to the original formula [Table 4].

Discussion:

Anthropologists, archaeologists, and forensic scientists have employed dental age estimation approaches worldwide. Accurate determination of dental age is crucial for identifying and reconstructing the biological characteristics of severely degraded, charred, or fractured remains. Even in advanced states, dental remains are regularly preserved and exhibit structural alterations that correlate to the individual's age.[12,13]

The Lamendin approach is a simple and basic method of age estimation that uses an extracted tooth. Due to the continuous formation of secondary dentin, it can be used as a dependable indicator to estimate age, even for individuals over the age of 21. The formation of secondary dentin follows a curved path instead of a straight path, and it is defined by chronological fluctuations.[14,15] Therefore, it is crucial to carry out research that can generate sufficient data to verify the dependability of this technique for calculating age. Premolars are preferred for these measures due to their single-root structure and large pulp canals. Lamendin technique was used on French people for the first time in 1992. Prince and Ubelaker carried out research in 2002 to devise a regression model to elucidate the morphological alterations in teeth, which were attributed to the impact of distinct populations in different geographical areas. The study group discovered a strong link between the projected age and the actual age. This study has developed a new regression equation primarily for the population of South India to ensure precise and reliable results. There was no noticeable difference between genders in the measured variables. This is consistent with the research by Lamendin et al. The level of root translucency demonstrated a significant positive connection with the chronological age of the overall sample, aligning with the results of Piyush et al. The study undertaken by Ackermann, Steyn, Piyush, et al., along with previous studies, produced consistent findings regarding periodontosis and root translucency. AB Acharya, Gupta, et al. exclusively employed the translucency measure in teeth that were sectioned on the ground and identified a strong positive correlation between dentinal translucency and chronological age. Martrille et al. (2007) did a study comparing four alternative approaches for calculating skeletal age in white and black individuals. The study concluded that Lamendin's method was the most accurate for those aged 41 to 60. Although there have been many studies investigating the accuracy of Lamendin's method in different age groups and communities, additional research is still required to ascertain its suitability in the field of forensic science.

Kvaal et al. devised a method to ascertain age by analysing six distinct teeth that are observable on an orthopantomogram (OPG) or periapical radiograph. The teeth mentioned are the maxillary central incisor, maxillary lateral incisor, maxillary second premolar, mandibular lateral incisor, mandibular canine, and first premolar.[16-19]

Gottlieb was the first to establish a correlation between alterations in dentition and the ageing process. In 1925, Bodecker presented evidence supporting the significance of secondary dentin's apposition in the context of the ageing process. Odontoblasts contribute to the development of secondary dentin over a person's lifetime, resulting in a reduction in the size of the tooth pulp cavity.[20,21] Secondary dentin deposition is currently recognrecognized as one of the contributing variables in the computation of dental age, along with attrition, cementum apposition, periodontal recession, apical translucency, and external root resorption.[22,23] A distinctive age estimation formula was developed using the ratios of length and width, as Kvaal's method demonstrated substantial mistakes in estimating age. The existing equation was subsequently assessed on a collective of 25 individual teeth.

Calculations were conducted to ascertain the ratios between tooth and pulp measurements, by Kvaal's approach, within the population of South India. The calculated age had a higher standard error of ± 11.5 years, in contrast to the ± 9.5 years standard error obtained in a study conducted by Kvaal and coauthors in the Norwegian population. The occurrence of this phenomenon can be attributed to ethnic inequalities and variances in the process of secondary dentin development among the population of South India. A recent study conducted by Babshet and his colleagues highlighted the imperative of formulating equations customized for certain populations, including ethnic variances. The absence of a substantial correlation between secondary dentin and age in the study can be attributed to the disparities in the formation of secondary dentin on the walls of the pulp chamber, which are influenced by factors such as race, ethnicity, nutrition, caries index, and lifestyle.

An evident correlation was found between the individuals' chronological age and the width ratios B, C, and W. The finding is consistent with the results documented by Bosmansa et al.[24]

Multiple studies have shown that the regression equations established by Kvaal et al are less significant in younger populations.[25,26] In contrast to previous research, our data demonstrate that we successfully determined the age of people in a group ranging from 21 to 75 years old, with an overall precision of ± 11.32 years. Regression models have been developed to estimate the age of individuals in the South Indian population using the results of this study.

The constraints of this study encompass the assessment of the newly formulated regression equation with a limited sample size. To strengthen the reliability of this technique for estimating the age of an adult using a single tooth, it is essential to validate the equation on a more extensive sample size that is tailored to both

the tooth type and the population being studied. Taphonomic and archaeological processes like burial can affect the accuracy of this method.

Conclusion:

Kvaal's and Lamendin's techniques are reliable in dental age estimation with Lamendin's method showing the nearest results. Future research complemented with multicentric analysis and a larger study population can validate its applicability in real-life forensic cases.

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