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Age estimation in Indian adult sample population using pulp to tooth area ratio of canines through Radio Visio graphy

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Abstract

Background: Age is one of the triads of vital information to determine the identity in cases where visual recognition is not possible. Teeth especially canines may be instrumental to estimate the age due to longest functional survival rate in the mouth and undergo less wear.

Aim & Objectives: The present study examines the application of the pulp/tooth area ratio in canines through Radio Visio graphy as age indicator in Indian sample population.

Materials & Methods: A total of 1000 subjects, 500 females and 500 males in the age range of 20-60 years were included. The sample was divided between the genders into 4groups I. e Group-I(20- 30years); Group-II(31 – 40years); Group-III(41 – 50years); Group-IV(51 – 60years). For each individual, the pulp tooth area ratio

(AR) was measured on Right upper canine (X1), Right lower canine (X2) & both canines (X1 X2).

Observations & Results: Pulp to tooth area ratio (AR) for males ranged from 0.051 to 0.198 whereas in females it was 0.051 to 0.198. The residual standard errors on obtaining the predicted age using the regression formula for the overall sample which ranges between 0.186 – 0.93 for group I, in group II it was 0.193 – 1.047, group III 0.170 – 0.885 whereas in group IV it was 0.179 – 0.736.

Conclusion: It was found that the regression equation derived from AR of the maxillary canine correlated with the subject's chronological age (2 years) as compared to the lower canines (3 years) in all the four groups.

Keywords: Age, Canines, Forensic, Pulp-tooth ratio, Radio Visio graphy

Introduction

In forensic investigations, estimating an individual's age, whether alive or dead, is a daunting task. This is useful in both civil and criminal cases, such as consent, juvenile offenders, kidnaps, rape, marriage, attainment of majority, competency as a witness, senior citizen concession, retirement benefits, and so on. It also plays an important role in creating a profile of a deceased person. [1-3]

Commonly used indications include secondary sex traits, bone maturation, height, weight, etc. The dental maturation indicator method has recently gained popularity as a useful tool for determining age. [2,4]

Teeth being the human body's toughest tissues are owing to persistence to a variety of environmental factors as well as mechanical, chemical, and thermal insults. Further a numerous varied genetic and acquired features may be responsible for the morphological entities recognizing the unique composition and shape. As a result, they can be used as ageing biomarkers. Additionally, teeth are favored tissues in forensic and archaeological studies since their development is not noticeably impacted by illnesses, medications, or endocrine conditions as is the case with bone. [5-7]

In children, radiographic tooth age estimation is based on the stages of tooth development, however in adults, pulp area reduction due to the continual deposition of secondary dentin throughout the course of life can be used.[6]

Kvaal et al. [8-11] proposed a number of length and breadth measurements for the tooth and pulp in addition to introducing an age estimation approach by indirectly evaluating secondary dentine deposition on radiographs. A comparable approach based on radiographic measurement of the pulp to tooth area ratio (AR) in canines was later proposed by Cameriere's et al. [12-16] Because they have a single root and the biggest pulp area for easy study, canines are preferred teeth. They also typically occur in later age groups and are less likely to wear out than other anterior teeth. [12-16]

The use of more sophisticated radiographic methods, such as radio Visio graphy, offers superior benefits such less radiation exposure, reproducibility, precision, and quick turnaround. It can help eliminate inter-observer bias when used in conjunction with computer-aided image analysis, resulting in better accuracy, reliability, and reproducibility. [17,18]

In order to develop a population-specific formula for age assessment, the current study evaluated the age estimation by measuring the pulp/tooth ratio in canines using radio Visio graphy among adult Indian sample population.

Materials & methods

A total of 1000 subjects, 500 females and 500 males in the age range of 20-60 years were included from the patients reported to the department of Oral Medicine and Radiology for routine dental checkup.

The sample was divided between the genders into 4 groups i.e Group-I (20- 30years); Group-II (31-40years); Group-III (41-50years); Group-IV (51-60years).

Subjects having the canines affected with caries, abrasion, erosion, fracture and canines that were Impacted, endodontically treated, supra-erupted & canines associated with Crowns /bridge or used as an abutment were excluded from the study.

Subjects meeting the inclusion criteria with healthy canines were informed briefly about the study protocol and a written informed consent was obtained.

Intra oral periapical images for maxillary and mandibular right canines were taken using the IOPA machine and sopex sensor with 60kV, 6mA and 0.05 seconds as exposure parameters.

All the radiation protection measures like wearing lead apron including ALARA principle were followed.

The outline of the canine and its pulp chamber was traced on the radio Visio graphic image. Twenty points from each tooth outline and ten for each pulp outline were identified and used to evaluate both tooth and pulp areas.

After completion of tracing, the program displayed the area of the tooth &its pulp chamber on the screen and later the morphological variable i.e., pulp tooth area ratio (AR) was derived.

Fig.1: Radio Visio graphic canine adobe photo shoot.

Fig. 2: Transferring the image to Pulp-tooth ratio.

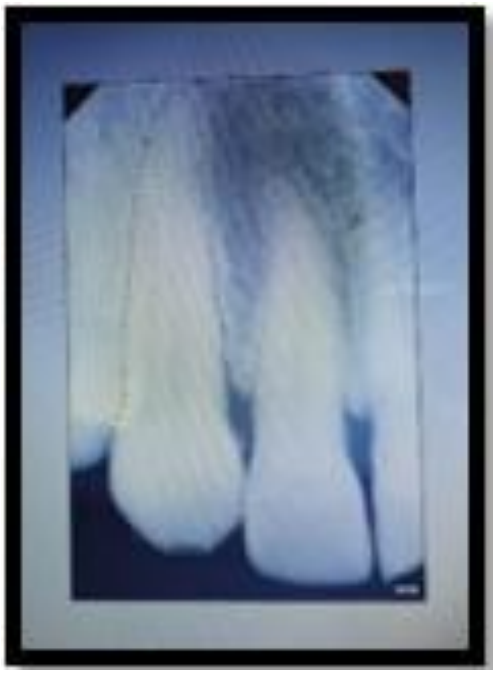


Fig. 3: Measuring Image of maxillary.

The image obtained on the computer screen through radio Visio graphy (Fig 1) was then photo edited using adobe Photoshop CS3 (Fig 2) using the magnetic lasso tool provided in this program. After completion of the tracing, the program displayed the area of the tooth and its pulp chamber. Later, the morphological variable, i.e., pulp/tooth area ratio (AR) (Fig 3) was derived.

Statistical Analysis

Pulp/tooth area ratio (AR) measurements were taken on the upper canine (X1), lower canine (X2), and both canines for each person (X1X2). By deducting the date of the radiograph from the date of birth, the chronological/actual age was recorded. A random sample of 20 radio Visio graphs was re-examined one week later to test intra-observer reproducibility. Age, gender, and morphological variables (AR) were loaded into a Microsoft 2019 EXCEL spreadsheet and examined for potential use as predictable factors for age estimation. Age and the predicted variables were compared using the correlation coefficients with SPSS software version 20 IBM, Chicago. In order to show any differences between the morphologic variables in regard to gender, Pearson correlation coefficient was used.

Observations & Results

A total of 2000 teeth from 1000 subjects were analyzed which included both upper (1000) and lower canines (1000) of different age groups ranging from 20-60 years where 500 subjects were females and 500 subjects were males. Pulp to tooth area ratio (AR) for males in the upper canine ranged from 0.052 to 0.198, 0.051–0.195 for lower canine and overall, it ranged from 0.051 to 0.198. AR for females in the upper canine ranged from 0.051to 0.198, 0.054–0.194 for lower canines and overall, it ranged from 0.051 to 0.198. To test the difference between male and female AR of canines, the unpaired 't' test was done. The upper canine and lower canine revealed a 'p' value which were statistically not significant suggesting that gender did not have any effect on the morphological variables (AR)

To assess the nature and degree of relation of morphological variables, i.e., pulp to tooth area ratio (AR) with actual age as given by subjects, Pearson's correlation coefficient was done. It was found that all the morphological variables were significantly correlated with age and have an inverse relation with each other.

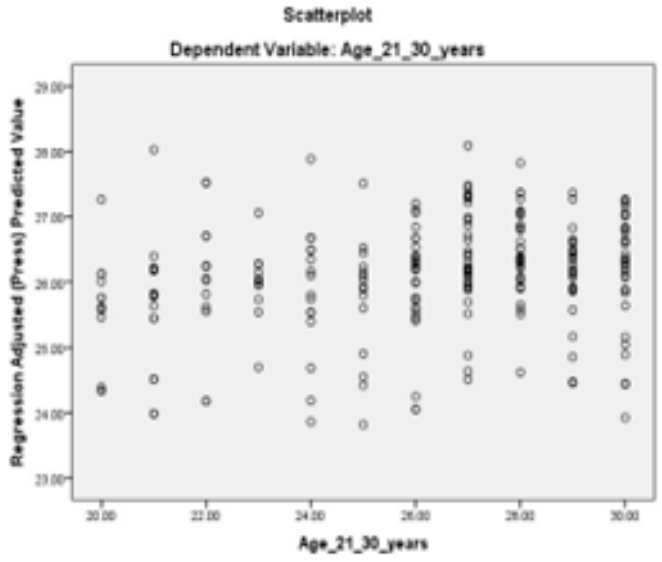
A regression model was developed for all the subjects in this study for AR and age to predict the chronological age which demonstrated the regression coefficients of all morphological variables to be highly significant (p = 0.000) (Table 1).

Group	Upper Canine	Lower Canine	Both
I	27.509-30.557X1	27.509-2.752X2	27.509-2.752X1–30.55X2+207.498X1X2
II	40.720-47.213 X1	40.720-51.719X2	40.72 – 51.71X1 – 47.21X2 + 460.68X1X2
III	62.132-169.364X1	62.132-179.249X2	62.13-179.24X1-169.36X2+1782.86X1X2
IV	44.603+148.239X1	44.603+135.617X2	44.60+135.61X1+148.23X2-1958.06X1X2
IV	44.603+148.239X1	44.603+135.617X2	44.60+135.61X1+148.23X2-1958.06X1X2

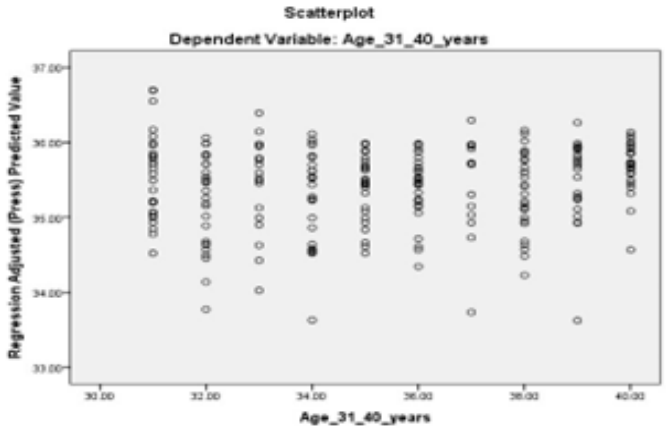
Table 1: The regression model utilizing AR yields the following linear regression formula to predict the chronological age in all the four groups.

The study population of group I showed a mean age of 26.07±3.034 and the mean AR of upper canine i.e X1 was 0.0950 ± 0.04099 whereas lower canine i.e X2 was 0.0868 ± 0.03640 and both the canines X1X2 was 0.0082 ± 0.00520. The study population of group II showed a mean age of 35.4177 ± 2.924 and X1 was 0.0902 ± 0.03140 whereas X2 was 0.0917 ± 0.02893 and both the canines X1X2 was 0.0080 ± 0.00318. The mean age of study population in group III was 45.7080 ± 2.79104 and the mean AR of upper canine i.e X1 was 0.0798 ± 0. .01935 whereas lower canine i.e X2 was 0.0787 ± 0.01260 and both the canines X1X2 was 0.0063 ± 0.00187. The mean age of study population in group IV was 54.9040 ± 2.72847 and the mean AR of upper canine i.e X1 was 0.0732 ± 0.01169 whereas lower canine i.e X2 was 0.0776 ± 0.01129 and both the canines X1X2 was 0.0057 ± 0.00110.

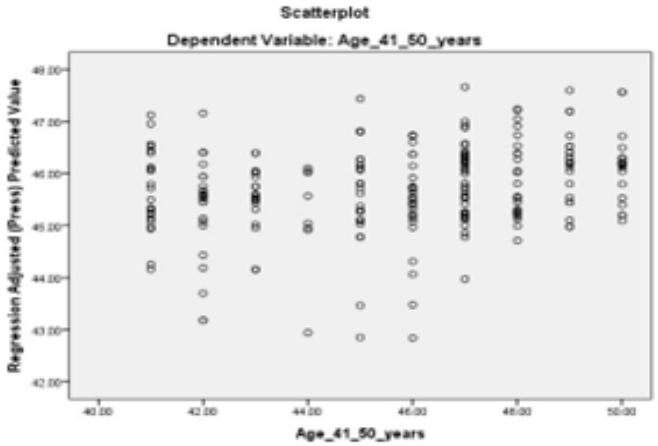
The actual versus predicted age on the regression plot shows that the regression model fits the trend of data reasonably well with only a few observations outside the boundary. (Graph 1,2,3,4)



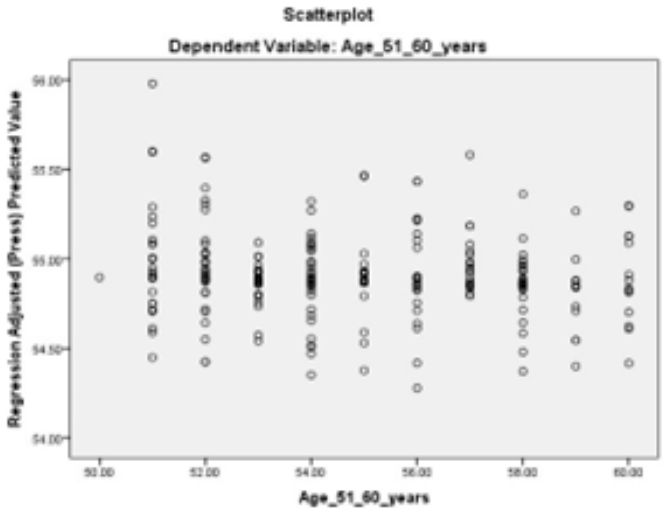
Graph 1: The actual versus predicted age on the regression plot in group I.



Graph 2: The actual versus predicted age on the regression plot in group II.



Graph 3: The actual versus predicted age on regression plot in group III.



Graph 4: The actual versus predicted age on the regression plot in group IV.

In this study, it was found that the regression equation derived from AR of the maxillary canine correlated with the subject's chronological age (2 years) as compared to the lower canines (3 years)

Discussion

Age estimation, a law enforcement procedure that aids in personal identification whether alive or dead is a daunting task. Accurate age estimation in human adult is an important issue in forensic sciences, anthropological situations, in addition to criminal and civil proceedings. To this end, forensic practitioner is requested to perform an age assessment on a living individual for legal requirements for age estimation as in case of refugee and asylum seekers, criminal responsibility, and child, falsification of age, competency and quantification of uncertainty. Whereas an accurate gender determination can be done by DNA analysis recently; age determination is not as straightforward issue.[19]

While cameriere et al in 2007 obtained high levels of accuracy in age prediction (mean error - 3 to 4.5 years), they advised that future research should investigate ''the effect of race and culture in model parameters''.[12] Indeed, others such as kvaal et al and Bodecker et al have also advocated the verification of age estimation methods on independent samples and some have concluded that best results are derived when population specific formulas are used. [11,19]

In the present study, we sought to estimate the AR in canines (upper, lower and both) in an adult Indian sample population using radio Visio graphy. Linear regression equations were derived for upper canine, lower canine and both using the AR to estimate chronological age. Additionally, the efficacy of these equations was also evaluated in different age groups.

Since the image is immediately visible on the computer as opposed to traditional radiographs, which require developing X-rays, the benefits of RVG include low time and simplicity of repetition. Precision, accuracy, and dependability are further benefits of using the present method in addition to less exposure and ease of reproducibility. So, in this study, we made an effort to employ this technique that does not require scanning or digitalization of conventional radiographs.

The results of the current investigation demonstrated that gender has no discernible impact on canine's AR ratios and also with research by Cameriere et al in Italian population. The consistency in the result among different sample populations might be attributed to the fact that dentin completely surrounds pulp, and hence the external factors like masticatory stress and attrition have little impact on the inner morphology of pulp in both males and females. The subjects in our study had different eating habits, so it appears that this is true independent of diet. [12-16]

According to the study conducted by Cameriere et al.,[13] the regression equation, with the considered variables, explained 84.9% of total variance (R2 = 0.849) with the standard error of estimate of 5.35 years and median of the residuals of 3.7 years. In the present study we got more accurate results. This could be attributed to the double sample size studied in our study.

Study conducted by Saxena et al., showed 99.7% variance and 0.60 standard error of the estimate, when selected variables were used. The study was conducted on Indian population. India has a population of mixed ethnicity and people belonging to various origins reside here but ethnicity was not considered in the study.[20]

In the present study, there was least significant difference between chronological and estimated age for

any of the age groups ('P' > 0.05) signifying that the derived formula is appropriate for all the selected age groups. This finding was consistent with the studies by Saxena[20] and Singaraju et al. [17]

The study's findings are encouraging, but they cannot be applied to other populations. The maxillary canines were the only single-rooted teeth included in the study since they are the longest-lasting and have the greatest pulp areas. But the approach cannot be used in situations where these teeth are gone.

When employing digital measurements, some concerns about the precision and accuracy of the measurements have been mentioned in the literature.

Thus, in the future, programmes for image analysis that can identify pulp outlines in radiography pictures may be created, which will be highly helpful in reducing the need for manual measurements of morphological parameters and likely lower both intra- and inter-observer variability.

Conclusion

The findings of this study support the validity of dental methods to assess the biologic age in order to help forensic odontologists to develop profiles of deceased people as well as age living subjects. As it is logical to think that population specific formulae are more accurate in estimating a subject's age, future research should focus on using larger samples that represent a variety of ethnic groups and geographic strata to develop precise universal formulae. The upper canines appear to be ideal for age estimation using the pulp tooth area ratio approach, but other teeth, such as incisors and premolars, may also need to be investigated in order to adopt more precise and accurate methods for age estimation.

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