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Age estimation using pulp/tooth area ratio: A digital image analysis

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Abstract

Age is one of the essential factors in establishing the identity of the person. Estimation of the human age is a procedure adopted by anthropologists, archeologists, and forensic scientists. Inspection of radiographs and subsequent comparison with radiographic images, in charts yield 'maturity scores' that help us to assess the age of an individual. Alternative approaches based on digitalization of panoramic radiographs and their computerized storage have recently become available that exploit image analysis to obtain nondestructive metric measurements of both pulp chambers and teeth, which can be used to assess the age of an individual. The purpose of the present study was to present a method for assessing the chronological age based on the relationship between age and measurement of the pulp/tooth area ratio on single-rooted teeth, using orthopantomographs and a computer-aided drafting program AutoCAD 2000.

Key words: Age estimation, AutoCAD2000, orthopantomographs

Introduction

Forensic odontology is the practice related to law. It can be considered as an area of specialization under dentistry as well as forensic medicine because knowledge of both the fields is vital for its activity.[1] Age is one of the essential factors of forensic odontology and is essential in establishing the identity of the person. Estimation of the human age is a procedure adopted by anthropologists, archeologists, and forensic scientists.[2] The estimation of age at time of death is often an important step in identification of human remains.[3] If the age can be accurately estimated, it will significantly narrow the field of possible identities that will have to be compared to the remains in order to establish a positive identification. Changes that are appreciable in teeth with increasing age are attrition, periodontal disease, secondary dentin deposition, root translucency, cementum apposition, root resorption, color changes, and increase in root roughness. By taking into consideration, these secondary changes in teeth with advancing age, various studies were done to estimate the age of an individual. Such research has resulted in multifactorial methods that help in age estimation.[2] The age-related changes in the dentition could be divided into three categories: formative, degenerative, and histological. The formative or developmental changes are good predictors of age in the early years, until age 12. Formative changes are subdivided into following stages: the beginning of mineralization, the completion of the crown, the eruption of the crown into the oral cavity, and completion of the root.[4]

Degenerative changes also provide data for age estimation. The obvious degenerative changes in adult dentition are color, attrition, and periodontal attachment level. Color change is highly variable and is closely related to diet and oral hygiene.[4]

The changes connected with age are the following:[5]

1. Attrition takes place from the wearing down of the incisal or occlusal surfaces due to mastication. This change is seen both macroscopically and microscopically.
2. Periodontosis, loosening of the tooth, or continuous eruption, is characterized by changes in the attachment of the tooth. This change again, is seen both macroscopically and microscopically.
3. Secondary dentin may develop within the pulp cavity; partly as a direct sign of aging and partly as a reaction against pathologic conditions like caries and

paradentosis. This change is seen only in the microscopic sections.
4. Cementum apposition may take place at the root and around it, particularly in connection with paradentosis. It is seen only in the microscopic sections.
5. Root resorption may involve both cementum and dentin.
6. Transparency of the root increases with age and is best appreciated in ground sections.

However, all these methods require extraction, and most of them require preparation of microscopic sections of at least one tooth from each individual. These methods therefore cannot be used in living individuals and in cases where it is not acceptable to extract teeth for ethical, religious, cultural, or scientific reasons.[6]

Radiography being a nondestructive method also plays a vital role in forensic dentistry to uncover the hidden facts, which cannot be seen by means of physical examination. Dental examination and comparison between antemortem and postmortem dental records and radiographs produce results with a high degree of reliability and relative simplicity. Radiographs are also helpful to determine the age of an individual by assessing the stage of eruption.[7]

A study of radiographs of the teeth is a nondestructive, simple method to obtain information.[8] Inspection of radiographs and subsequent comparison with radiographic images, drawings, and descriptions in charts yeilds 'maturity scores' that help us to assess the age of an individual.[9]

Alternative approaches based on digitalization of panoramic radiographs and their computerized storage has recently become available. These procedures exploit image analysis to obtain nondestructive metric measurements of both pulp chambers and teeth, which can be used to assess the age of an individual. Forensic odontologists can utilize these techniques that are relatively precise and accurate, and avoid the bias inherent in observer subjectivity.[10]

The purpose of the present study was to present a method for assessing the chronological age based on the relationship between age and measurement of the pulp/tooth area ratio on single-rooted teeth, using orthopantomographs and a computer-aided drafting program.

Materials and Methods

This study was a retrospective study of 200 rotational pantomographs collected from patients coming to the various departments of V. S. Dental College and Hospital, Bangalore. These radiographs were taken as a part of the routine treatment that is being rendered to the patient.

Inclusion criteria
1. Pantomographs selected were of the patients aged between 18 and 72 years.
2. The selected tooth on the orthopantomograph, the right maxillary canine was fully erupted into the oral cavity.
3. The root of the canine was fully formed.

Exclusion criteria
1. Teeth with any pathology, such as, caries or periodontitis or periapical lesions, which would alter the surface area of the tooth.
2. Malaligned canines or rotated canines.
3. Canines with any prosthetic fittings.

Methods

The selected orthopantomographs were digitized using ASTRA 4000 U X-ray scanner and the images were recorded in a computer file. Radiographic images of the canine were then processed using computer-aided program AutoCAD 2000.

Twenty points were marked on the surface of the tooth outline and ten points were marked on the surface of the pulp outline of the right maxillary canine, to obtain the tooth surface area and the pulp surface area, respectively.

To minimize interobserver variations, the points on the tooth and pulp surface were selected in such a way that they yielded following specific measurements:

T: Maximum tooth length
R: Maximum root length
P: Maximum pulp length
A: Root and pulp width at CEJ
C: Root and pulp width midway between apex and CEJ
B: Root and pulp width midway between measurement levels A and C

The chronological age of the patient was calculated by substracting the date of radiograph from the date of birth of the patient.

Morphological variables and the chronological age of the patient were entered in Microsoft Excel spread sheet for use of age estimation. Correlation coefficient was evaluated between age and predictive variable, that is, pulp/tooth surface area. A multiple linear regression model was then developed to estimate the age of the individual.

The estimated age was then compared with the chronological age of the individual.

Results

Student's t test was used to compare the estimated age and chronological age of the different groups and found the P value to be 0.86 [Table 1]. Since $P > 0.05$, it was concluded that there is no significant difference between estimated age and chronological age. The correlation coefficient 'r' between the two variables, that is, the chronological age and the estimated age, was found to be 0.99, which indicated that the two variables are linearly related to each other [Table 1, Figure 1].

In this study, the entire sample was distributed into three different age groups – 18–30, 31–50, and 51–70 years – to observe the effect of this method on different age groups. The observed correlation coefficients 'r' were 0.89, 0.97, and 0.96, respectively, which indicated that the chronological age and the estimated age in all the three age groups were closely related to each other [Tables 2-4] [Figures 2-4].

Similarly, the effect of gender on age estimation was also determined in this study, and found that gender had no significant influence on age [Tables 5 and 6] [Figures 5 and 6].

Discussion

In our study, the analyzed results showed that the P value was >0.05 [Table 1], which meant that there is no significant difference between estimated age and chronological age. This was in accordance to the previous studies conducted by Cameriere *et al*.[10] and Bosmans *et al*.[8] The correlation coefficient 'r' was found to be 0.99 [Table 1]. This confirms that estimating the age using pulp/tooth area ratio is relatively accurate.

Previous studies have shown that with advancing age the size of the dental pulp cavity is reduced as a result of secondary dentin deposition, so that measurements of this reduction can be used as an indicator of age. Kvaal *et al*.[9] conducted a study to find a method to estimate the chronological age of an individual from measurements of size of the pulp on full mouth dental radiographs. They used radiographs of six different teeth – maxillary central and lateral incisors and second premolars, and mandibular lateral incisors, canines, and first premolars. They tried to correlate age with various factors like pulp/root length, tooth/root length, and pulp/root width at three different levels. They found out that the width of the pulp had a strong correlation with age.[6]

Later, Bosmans *et al*.[8] applied Kvaal's dental age calculation technique on panoramic dental radiographs, thereby avoiding the cumbersome process of taking many periapical radiographs. They also in their study found pulp width to be closely associated with age.

In the present study, we also used panoramic radiographs, as in the study of Bosmans *et al*.[8] and we observed that estimated age was modeled as a linear function of the chronological age. Hence this study also confirms the fact, that the width of the pulp is a better indicator of the age, which is in consistence with previous studies conducted by Kvaal [9]and Solheim[11], Bosmans *et al*.[8], Cameriere *et al*.[10]

Table 1: Comparison of chronological and estimated age of all the subjects

Age	Sample size	Mean age (yrs)	*P* value*	Correlation coefficient
Chronological age	200	31.305	0.859 (ns)	0.993
Estimated age	200	31.529		

*Student's *t* test (two-tail); ns: not significant

Table 2: Comparison of chronological and estimated age of subjects in the age group 18–30 years

Age	Sample size	Mean age (yrs)	*P* value*	Correlation coefficient
Chronological age	120	22.567	0.294 (ns)	0.899
Estimated age	120	23.028		

*Student's *t* test (two-tail); ns: not significant

Table 3: Comparison of chronological and estimated age of subjects in the age group 31–50 years

Age	Sample size	Mean age (yrs)	*P* value*	Correlation coefficient
Chronological age	55	38.873	0.911 (ns)	0.979
Estimated age	55	38.736		

*Student's *t* test (two-tail); ns: not significant

Table 4: Comparison of chronological and estimated age of subjects in the age group 51–70 years

Age	Sample size	Mean age (yrs)	*P* value*	Correlation coefficient
Chronological age	25	56.6	0.928 (ns)	0.961
Estimated age	25	56.48		

*Student's *t* test (two-tail); ns: not significant

Table 5: Comparison of chronological and estimated age of all male subjects

Age	Sample size	Mean age (yrs)	*P* value*	Correlation coefficient
Chronological age	106	32.839	0.812	0.992
Estimated age	106	33.279		

* Student's *t* test (two-tail); ns: not significant

Table 6: Comparison of chronological and estimated age of all female subjects

Age	Sample size	Mean age (yrs)	*P* value*	Correlation coefficient
Chronological age	94	29.574	0.991	0.995
Estimated age	94	29.555		

*Student's *t* test (two-tail); ns: not significant

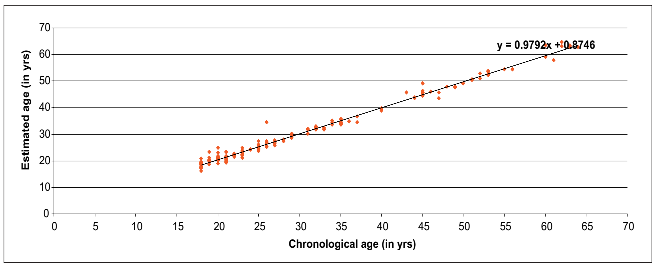

Figure 1: Scatter plot showing the relation of estimated age and known age in the entire sample

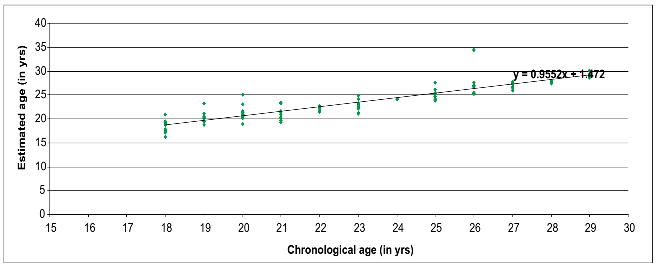

Figure 2: Scatter plot showing the relation of estimated age and known age in the age group 18–30 years

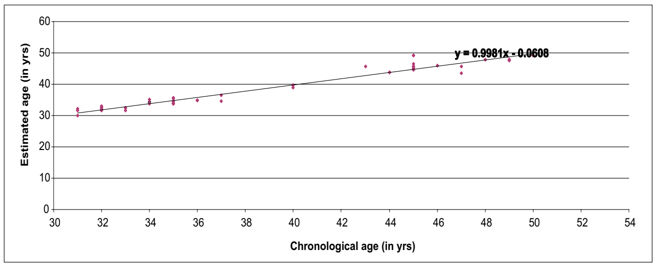

Figure 3: Scatter plot showing the relation of estimated age and known age in the age group 31–50 years

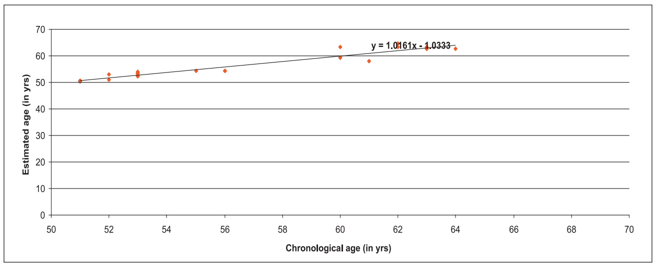

Figure 4: Scatter plot showing the relation of estimated age and known age in the age group of 51–70

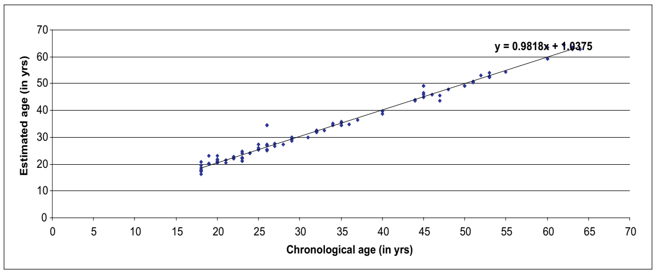

Figure 5: Scatter plot showing the relation of estimated age and known age in males

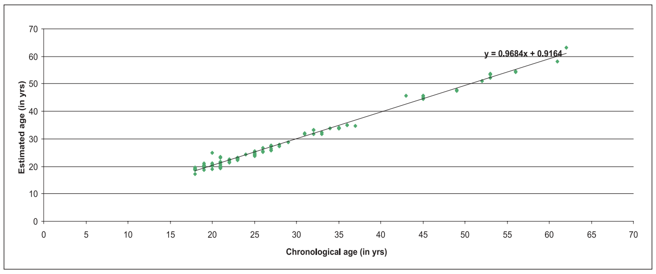

Figure 6: Scatter plot showing the relation of estimated age and known age in females

In this study, the entire sample was distributed into three different age groups – 18–30, 31–50, and 51–70 years. The observed correlation coefficients 'r' were 0.89, 0.97, and 0.96 [Tables 2-4], respectively, which indicated that the chronological age and the estimated age in all the three age groups were closely related to each other.

Similarly, the effect of gender on age estimation was also determined in this study, and we found that gender had no significant influence on age [Tables 5 and 6]. This is in accordance with the original study carried out by Cameriere *et al.*[10]

In the due course of our study, we however found that, this method of age estimation has certain limitations. This method of age estimation cannot be employed in multirooted teeth, as accurate measurements of multirooted teeth were difficult to perform. Similarly, as the curved arch of the jaw is projected on to a flat film, there will always be certain amount of distortion when measuring the image presented there. To compensate for the amount of distortion, we chose the tooth of study on a particular side of the radiograph, that is, we chose only the right maxillary canine, so that the amount of distortion is uniform in all the radiographs. Therefore, it is impending to be seen whether this distortion has any effect on accuracy of age estimation. Apart from the aforementioned limitations, the cost involved in setting up of the software is also high. So it is suggested that in future, further studies can be taken up to estimate the age using other single-rooted teeth and then determine the completeness of this method of age estimation, so that it may become a method of choice for forensic odontologists on a regular basis.

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