Age estimation from pulp/tooth area ratio by panoramic radiographs: In Kashmiri population

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Abstract

Introduction: The aim of this study was to determine age by pulp/tooth area ratio (PTR) using three mandibular teeth by Panoramic Radiographs.

Materials and Methods: A total of 225 panoramic radiographs of Kashmiri subjects (108 males and 117 females), aged between 15 and 70 years were analyzed. According to Cameriere et al measurements of the pulp and tooth areas were done. The morphological variables i.e pulp area, tooth area, pulp tooth ratio, age and the subject's gender were entered in a Microsoft Excel spreadsheet for use as predictive variables for age estimation. Chronological age of an individual was calculated by subtracting the birth date from the date on which the radiographs were exposed for that particular individual.

Results: It was found that the 2nd premolar was the most closely correlated with age(r=-0.951) and SEE 3.32 years followed closely by canine (r=-0.931) and SEE of 3.65 years. The 1st premolar revealed the lowest correlation (r=-0.899) and SEE of 4.72 years.

Conclusion: As the development of teeth varies among populations and is genetically determined, it becomes imperative to derive population specific data bases. From the results of this study, it may be concluded that the use of Cameriere's age-related variables in lower premolars and canine and the application of the new regression formulae on data obtained from orthopantomographs lead to accurate age estimates, if at least the selection criteria are respected and good quality orthopantomographs with clear radiological images are used.

Keywords: Age estimation, pulp tooth ratio, OPG, Kashmiri population, Regression equation.

Introduction

There are three main elements in the procedure of anthropological investigation and the identification of exhumed human remains: race determination, sex determination and age determination at the time of death. The most difficult one to determine is the age.[(1)] Tooth wear is influenced by various external factors (masticatory function, type of food, timing and sequence of tooth eruption), tooth form, position of teeth, thickness and hardness of enamel and predisposition to enamel hypoplasia. However, apposition of secondary dentin is a continuing, regular process which is only modified by caries or particular abrasion. Secondary dentin has been studied by sectioning and radiography. The study of tooth radiographs is a nondestructive and simple process which can be applied to both living and deceased persons, in contrast to other time consuming, expensive, less reliable and destructive methods which may not be acceptable for ethical, religious, cultural or scientific reasons. Further, procedures such as digitization of panoramic radiographs and computer assisted image analysis avoid the bias inherent in observer subjectivity and improve reliability, accuracy and precision.[(2)] After tooth eruption, it is well known that the size of the pulp cavity decreases gradually with age, because of the deposition of secondary dentine in the pulp cavity wall. This process is caused by the continual secretion of dentinal matrix by odontoblasts (physiological secondary dentinogenesis). Dentine is a living tissue containing odontoblasts which form the tooth. During a person's lifetime, for both physiological and pathological reasons (attrition, abrasion, erosion, caries), the odontoblasts deposit layers of secondary dentine, which gradually obliterates the pulp chamber. The mean rates of increasing dentinal thickness have been found to be 6.5 mm/year for the crown and 10 mm/year for the root. The effect is a progressive increase in dentinal thickness of 0.45 mm (17.1%) and 0.60 mm (24.3%) in the crown and root areas, respectively.[(3)] so the present study was done to estimate age using OPG by pulp/tooth ratio in Kashmiri population.

Materials and Methods

A total of 225 panoramic radiographs of Kashmiri subjects, aged between 15 and 70 years were analyzed. These panoramic radiographs were taken at the nearby radiology clinic using care stream CS 8000C. The patient's identification number, sex, age and date of radiographic taking were recorded. Protocols of the study and for radiographs collection of human subjects were approved by internal ethical committee of the institute.

Inclusion Criteria:

1. Age range: 15–70 yrs.

2. Mandibular first premolar, second premolar and canine are fully erupted into the oral cavity.
3. The root of the premolars and canine is fully formed.

Exclusion Criteria: Individuals with the following conditions were excluded from the present study:

1. Teeth with any pathology, such as, caries or periodontitis or periapical lesions, that would alter the surface area of the tooth.
2. Teeth with any prosthetic fittings and orthodontic appliances.
3. Fractured teeth.
4. Severely attrited teeth secondary to para-funtional habits.
5. Teeth with any developmental anomalies.

Unwilling patients were excluded from the study.

Measurements according to Cameriere et al: Measurements of the pulp and tooth areas were done according to Cameriere et al.[1] radiographs were saved as high resolution JPEG files on a computer and imported to AutoCAD 2010 software programme. A minimum of 30 points from each tooth outline and 15 points from each pulp outline has been identified and connected with the line tool on AutoCAD's draw toolbox. The pulp and tooth areas were measured using the point and line tools on the draw toolbox and the pulp/tooth area ratio (PTR) calculated correlation coefficients were evaluated between chronological age and morphological variables. Estimated age was obtained using morphological variables for each type of tooth. Single linear and multiple linear regression equations were developed by selecting those variables that contributed significantly to age estimation.

Statistical Methods: Statistical software SPSS and Microsoft Excel were used to carry out the statistical analysis of data. Descriptive statistics of data including percentages, means, standard deviations and ranges were reported. Pulp tooth ratios derived from the various teeth were subjected to linear (single tooth) and multiple (tooth combinations) regression analysis. The correlation coefficients (r) for single and multiple teeth were compared to ascertain which of them had a better relationship with age. The significance of correlation coefficients was ascertained by t-tests. The standard error of estimate (SEE), which reflects the accuracy of prediction, was calculated to predict the deviation of the estimated age from the actual age. Graphically the data was presented by bar diagrams. A P-value of less than 0.05 was considered statistically significant.

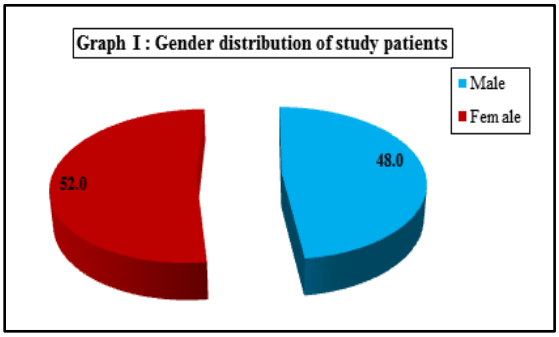
Results

Table 1: Age distribution of study patients

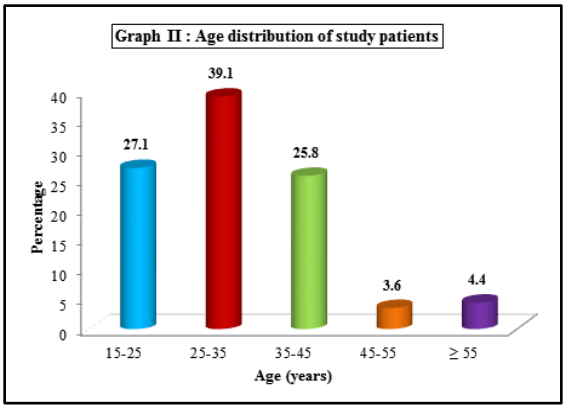
Age (years)	Frequency	Percentage
15-25	61	27.1
25-35	88	39.1
35-45	58	25.8
45-55	8	3.6
≥ 55	10	4.4
Total	225	100
Mean±SD=31.3±10.78		

Table 2: Gender distribution of study patients

Gender	Frequency	Percentage
Male	108	48.0
Female	117	52.0
Total	225	100



Graph I: Gender distribution of study patients



Graph II: Age distribution of study patients

Table 3: Descriptive statistics of pulp/tooth ratio of the canine, 1st premolar and 2nd premolar of study patients

Tooth	Mean	SD	Min	Max
Canine	0.149	0.033	0.0268	0.2146
1st premolar	0.135	0.036	0.0068	0.2111
2nd premolar	0.139	0.033	0.0242	0.1926

Table 3 explains the descriptive statistics of pulp/tooth ratio of the canine, 1st premolar and 2nd premolar of study patients.

We can see that mean pulp tooth ratio of canine in study sample is 0.149 with SD of 0.033, min pulp tooth ratio 0.0268 and max 0.2146. Similarly mean pulp tooth ratio of 1st premolar in study sample is 0.135 with SD of .036, min pulp tooth ratio 0.0068 and max 0.2111 and in 2nd premolar mean pulp tooth ratio 0.139, SD of .033, min pulp tooth ratio 0.0242 and max .1926.

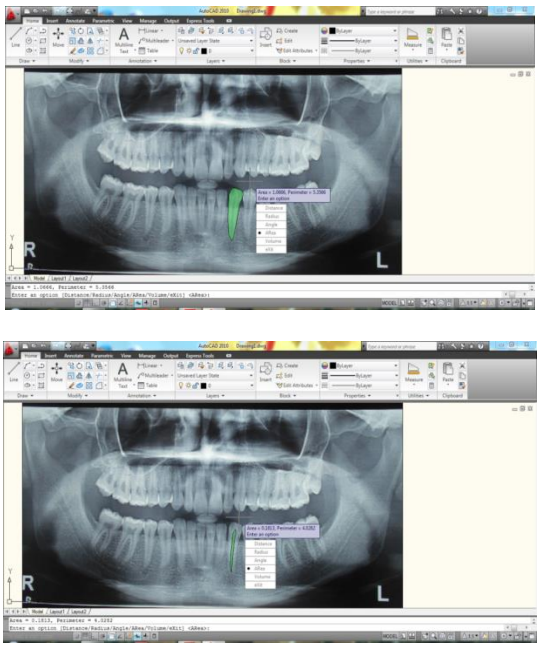
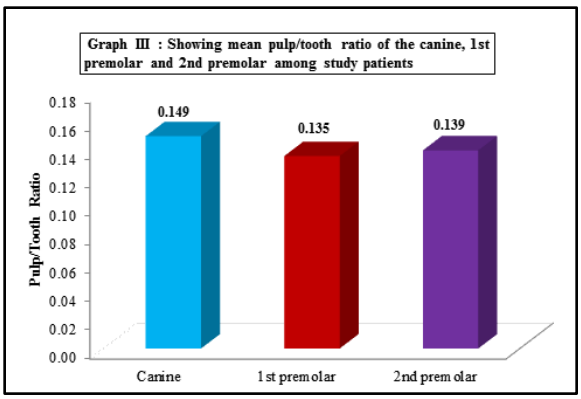


Fig. 1: AutoCAD 2010 software that was used for measuring pulp area and tooth area



Graph III: Graph showing pulp/tooth ratio of the canine, 1st premolar and 2nd premolar of study patients

Table 4: Regression equation for the canine, 1st premolar and 2nd premolar

Tooth	Regression Equation	R	r^2	SEE	P-value
Canine	Age = 75.65 – 296.7×PTR_C	-0.931	86.6%	3.95	<0.001
1st Premolar	Age = 67.39 – 266.9×PTR_PM1	-0.899	80.9%	4.72	<0.001
2nd Premolar	Age = 73.82 – 306.9× PTR_PM2	-0.951	90.5%	3.32	<0.001

Table 5: Regression equation for various tooth combinations

Tooth Combination	Regression Equation	r	r^2	SEE	P-value
Canine+1st premolar	Age = 75.3 – 193× PTR_C – 113×PTR_PM1	-0.951	90.4%	3.36	<0.001
Canine+2nd premolar	Age = 76.8 – 125× PTR_C – 193×PTR_PM2	-0.967	93.5%	2.75	<0.001
1st premolar+ 2nd premolar	Age=74.3 – 90.1× PTR_PM1 – 222× PTR _PM2	-0.964	92.9%	2.89	<0.001
Canine+1st premolar + 2nd premolar	Age = 76.4 – 97.5× PTR_C – 60.1× PTR_ PM1 – 162×PTR_PM2	-0.972	94.4%	2.57	<0.001

Linear regression equations were determined separately for the individual teeth and tooth combinations.

i. Regression equation for Canine
Age = 75.65 – 296.7×PTR_C

ii. Regression equation for 1st Premolar
Age = 67.39 – 266.9×PTR_PM1

iii. Regression equation for 2nd Premolar
Age = 73.82 – 306.9× PTR_PM2

iv. Regression equation for Canine+1st premolar
Age = 75.3 – 193× PTR_C – 113×PTR_PM1

v. Regression equation for Canine+2nd premolar
Age = 76.8 – 125× PTR_C – 193×PTR_PM2

vi. Regression equation for 1st premolar+ 2nd premolar
Age=74.3 – 90.1×PTR_PM1–222×PTR_PM2

vii. Regression equation for Canine+1st premolar+ 2nd premolar
Age = 76.4 – 97.5× PTR_C – 60.1×PTR_PM1 – 162×PTR_PM2

Where PTR=pulp tooth ratio, c=canine, PM1= 1st premolar, PM2=2nd premolar.

Discussion

Only aging process and regressive changes of teeth are helpful at adult age.[4] By taking in consideration, secondary changes in teeth with advancing age various studies were done to estimate the age of an individual. Such research has resulted in multi-factorial methods that help in age estimation.[5] Teeth may be better preserved than other parts of the body and thus give a better indication of age.[6] With advancing age

secondary dentine is deposited along the wall of the dental pulp chamber leading to a reduction in the size of the pulp cavity. Changes that occur with advancing age can be evaluated from Orthopantomography (OPG) provides a complete view of the teeth and both jaws in one image and is therefore commonly applied in dentistry.[7] A decrease in the volume of pulp cavity by secondary dentine formation is known to occur with age.[8] In 1925 Bodecker et all correlated the opposition of secondary dentin with age.[9] In 1995, Kvaal et al.[10] introduced a method of age estimation which was based on periapical radiographs, while Paewinsky et al in 2004 also checked the applicability of this method on orthopantomograms.[7] Rakesh Kumar Dumpala et al 2013[11] compared age estimation from pulp tooth ratio with hand wrist radiographs and found pulp tooth ratio better comparatively variations in pulp/tooth area ratio as an indicator of age was first time conducted by Cameriere et al[12] in 2004 and results obtained were promising. However they advised that in future research should done taking in account the effect of race and culture. Babshet et al in 2011[13] found that Cameriere's formula, cannot be applied to the Indian population.

In our study mandibular single rooted teeth were chosen for a number of reasons: they are the teeth which are often present in old age, there are less chances of attrition or abrasion because of any sort of work, and these are single root teeth with the largest pulp area hence easy to analyse.[14] There are less chances of trauma to these teeth as compare to incisors.[15] Other studies by Jeevan et al in 2011[16] Cameriere et al in 2009[14] showed that gender has no significant influence on these morphological variables of all types of teeth. This may be because pulp is surrounded by dentin all around, so external influences like masticatory stresses, attrition may have minimal influence on the inner morphology of pulp in both males and females.[16] The inter and intra observer measurements were insignificant in the present study. Similarly, other studies done by Camerier et al (2009)[14] Camerier et al (2012),[17] Paewinsky et al,[7] Jeevan et al in 2011,[16] and Jaklin Fekri et al in 2011[18] also did not reveal any statistically significant intra-observer differences. This may be because of better software used for measurements which might have nullified the variations. Roberto Cameriere et al in 2012[17] concluded that the use of Cameriere's age-related variables in lower premolars and the application of the new regression formulae on data obtained from orthopantomographs lead to accurate age estimates as seen in our study also. It also differs from other radiographic studies which evaluated reduction in the pulp chamber and root canal. For example, Kvaal et al. and Bosmans et al observed recognizably higher age correlations when the mandibular teeth were used in combination rather than alone same results are seen in our study too. M.B. Jeevan et al in 2011[16] stated that population specific formulas are more precise in determining age in individual subjects, however further research should aim at involving larger samples which include varying geographic regions and races to arrive at a common formula with this background we conducted the present study to drive a population specific formula for the people of Kashmiri origin. Ivan Galić et al conducted a study in 2011[19] also conducted a similar study with promising results.

Conclusion

From the results of this study, it may be concluded that the use of Cameriere's age-related variables in lower premolars and canine and the application of the new regression formulae on data obtained from orthopantomographs lead to accurate age estimates, if at least the selection criteria are respected and good quality orthopantomographs with clear radiological images are used. Future research modifying the presented technique, together with expected further improvements in peri-apical radiography, may provide an easy and optimized dental age estimation technique. The higher image quality of this technique will probably narrow age estimation error and improve dental age estimation Although OPGs are superior to smaller peri-apical films in their diagnostic examination, it is generally accepted that a radiographic image of a finite site found on an OPG is less clear than that shown by a peri-apical film. The image quality of orthopantomograms has also been shown to depend to a great extent on the patient's sex and age. In the future, better software image analysis programs should be used for the measurements so as to reduce the manual measurement errors.

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