Research Article

Applicability of Pulp Tooth Area Ratio in Age Estimation using Mandibular Premolars

Dr. Dipshikha Bajracharya[1], Dr. Bidhata Ojha[1], Dr. Sushmit Koju[1], Dr. Nisha Maharjan[1], Dr. Ankit Shah[2]

[1]Department of Oral and Maxillofacial Pathology, Kantipur Dental College and Teaching Hospital, Kathmandu, Nepal

[2]Department of Oral Medicine and Radiology, Kantipur Dental College and Teaching Hospital, Kathmandu, Nepal

Corresponding author: Dr. Dipshikha Bajracharya; Email: drdipshikhabaj@gmail.com

ABSTRACT

Introduction: Age estimation is an important parameter in forensic for identification of individuals. Cameriere developed pulp tooth area ratio as age estimation method in Orthopantomogram. Objective of this study was to use Pulp tooth area ratio of mandibular premolars and derive population-specific equations for age estimation.

Materials and Method: A retrospective study was conducted in Department of Oral and Maxillofacial Pathology, Kantipur Dental College and Teaching Hospital from June 2021 to November 2021 after ethical clearance no 10/021. Total 392, Orthopantomograms of patients aged 17- 50 years with mandibular premolars were retrieved from Department of Oral Medicine and Radiology. The radiographic images were saved as JPEG file and images of premolars were processed using Image J software. Pulp and tooth area were measured and their ratio was calculated.

Result: There were 178 males and 214 females with mean age of 22.39 years. Paired T tests showed good intra observer agreement between mandibular premolars. In our study pulp tooth area ratio ranged from 0.0109 to 0.2307 for 45, 0.0456 to 0.2030 for 44, 0.0413 to 0.2239 for 35 and 0.0639 to 0.2204 for 34. Linear regression analysis generated several formulae for all mandibular premolars which was statistically significant. Derived equations were used to test for accuracy in the 40 new samples which showed mean accuracy error between 5.65 to 6.40 years.

Conclusion: Derived equations from Pulp tooth area ratio of mandibular premolars can be used for age estimation in young adults from Nepalese population sample.

KEYWORDS: Age; orthopantomograms; pulp/tooth area.

INTRODUCTION

Age estimation is an important parameter in forensic medicine which allows easier identification of individuals.[1,2] Teeth are resistant to mechanical, chemical and thermal influences from the environment. Hence, various age estimation methods are based on dental tissues, among which radiograph is being accepted these days.[3]

Cameriere et al. proposed a method of age estimation in Italian Caucasian population which measured the pulp tooth area ratio in radiographs and found it best correlated with chronological age.[4] This method initially studied maxillary canine followed subsequently by studies on molars, canines and premolars.[5,6,7,8] However, this method of age estimation needs further validation in different population samples.

Hence, the aim of our study was to use Cameriere 's method of age estimation in Orthopantomograms (OPG's) using pulp/tooth area ratio of mandibular premolars on Nepalese population sample and derive population-specific equations for a more accurate estimation of age.

MATERIAL AND METHODS

A cross sectional retrospective study was conducted in Kantipur Dental College Teaching Hospital and Research Centre (KDCH) after obtaining ethical clearance from the Institutional Review Committee Ref no. 10/021. The

study was conducted form June 2021 to November 2021 in Department of Oral and Maxillofacial Pathology. The study was conducted in Orthopantomograms (OPGs) wherein good quality standard OPGs with presence of normal anatomical structures, adequate resolution and contrast were collected from the archives of Department of Oral Medicine and Radiology. OPGs of patients aged between 17-50 years with intact mandibular premolars (34, 35, 44 and 45) were included in the study. Radiographs with lost or extracted mandibular premolars as well as those with root canal treatments, crown restorations, mutilated teeth, severe caries or atypical dental anatomy which may interfere with the measurement were excluded. Also, Radiographic evidence of rotated teeth or large area of enamel overlap between neighbouring teeth were excluded.

The sample size was calculated using formula: Sample size (N) = $(z\alpha+z\beta)2$ x2xSd2 /d2
$Z\alpha$ - z deviate corresponding to the α error rate =1.96 for 95% reliability
$z\beta$ - z deviate corresponding to the β error rate = 0.84 at 80% power
Sd- the mean standard deviation = 0.01+0.02/2=0.015
d- mean difference between two groups= m1-m2=0.038-0.035=0.003 (Gulsahi et al. 2018)[9]
Sample size (N) = $(1.96+0.84)^2$ x 2x $(0.015)^2/0.003^2$ = 0.003528/ 0.000009
Sample size (N) = 392

After collection of the OPG's, the radiographic images were saved as high-resolution JPEG files on a desktop computer. Radiographic images of premolars were processed using Image J 1.52 p (National Institutes of Health, USA). Twenty points from each tooth outline and ten points for each pulp outline were identified and used to evaluate tooth and pulp areas (Figure 1a, b). Tooth and Pulp area was measured and their ratio was taken as AR (Pulp/tooth area).[3] The data regarding the individual's gender and chronological age at the time of OPG, was recorded. The Pulp area and tooth area was recorded and their ratio (AR) was calculated and recorded in an excel file for age estimation.

All measurements were carried out by same observer with experience of this technique. To obtain an estimate age, a linear regression model was developed using AR of 45, 44, 34 and 35. To test intra observer reproducibility, random 40 OPGs were re examined after an interval of two weeks.[3] Likewise, to test the accuracy of the regression formula new samples (10% of the total sample) which was not used for the study was taken.[10] The mean accuracy error was calculated by chronological age − estimated age.

All the data were entered in Microsoft excel sheet and statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 21 software. Confidence interval was set at 95%.

RESULTS
The study included of total 392 Orthopantomograms (OPG's) retrieved from the Department of Oral Medicine and Radiology, which comprised of 178 males and 214 females (Table 1). The chronological age of the OPG's ranged from 17-49 years with the mean age of 22.39 years.

In the present study, 40 OPG's were re-examined to check for intra observer variability. Paired T tests showed good intra observer agreement between the measurements carried out for all the mandibular premolars. The Pulp tooth area ratio ranged from 0.0109 to 0.2307 for 45, 0.0456 to 0.2030 for 44, 0.0413 to 0.2239 for 35 and 0.0639 to 0.2204 for 34. In our study, we found that there was decrease in the pulp tooth area ratio as the age increased (Figure 2).

Linear regression analysis defining age as a dependent variable, the pulp tooth area ratio of mandibular premolars had generated several formulae. The t-value of AR in the regression equation was statistically significant (P< 0.05) (Table 2). In the present study, the derived equations were used to test for accuracy in the 40 new samples. The result showed mean accuracy error -2.20 to 4.83 for 45, -0.81 to 5.38 for 44, -6.40 to 5.65 for 35, - 5.64 to 4.82 years for 34. When, the reference value of AR ranged 0.01-0.30 was placed for mandibular premolars in the derived equation, the predicted age was calculated as 15-26 years (Figure 3).

Table 1. Age and Gender Distribution of the study groups

Gender	Age (years)			Total (N)
	17-27	28-38	39-49	
Male	164	12	2	178
Female	190	20	4	214
Total	354	32	6	392

Table 2. Regression equations using mandibular premolars

S.no	Tooth	Equation	R	R²	SE	t-value	Sig
1	45	Age = 27.387- 42.639 AR	0.151	0.058	4.733	-4.87	0.00
2	44	Age = 26.358-32.463 AR	0.194	0.038	4.783	-3.912	0.00
3	35	Age = 27.751-46.902 AR	0.269	0.072	4.696	-5.511	0.00
4	34	Age = 26.811-38.673 AR	0.205	0.042	4.772	-4.133	0.00

AR − Calculated Pulp/tooth area
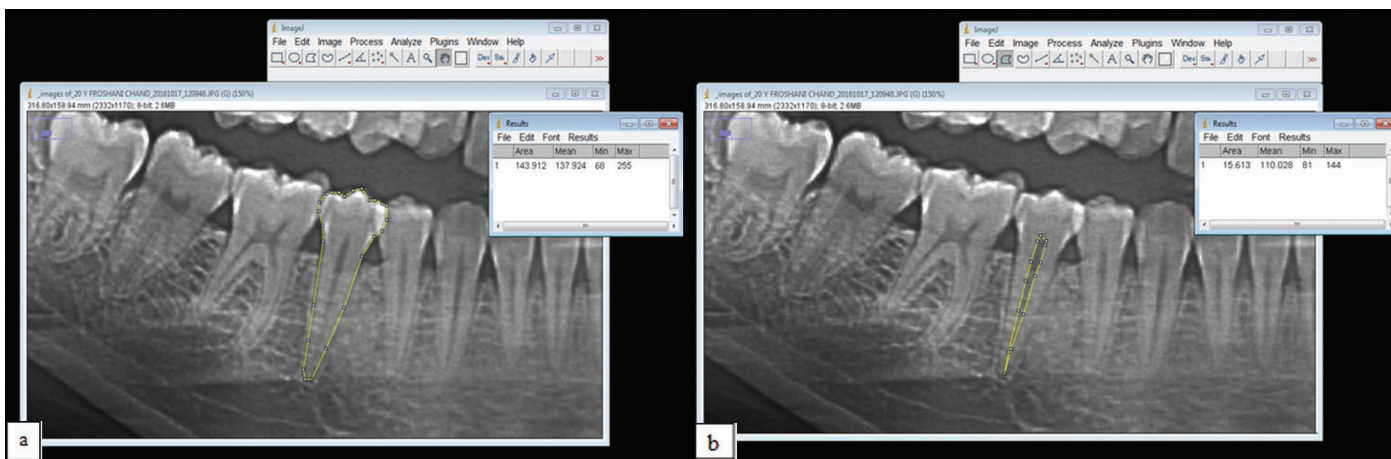
Figure 1. a. Measurement of the Premolar from tooth area; b. Measurement of the Premolar from Pulp area.
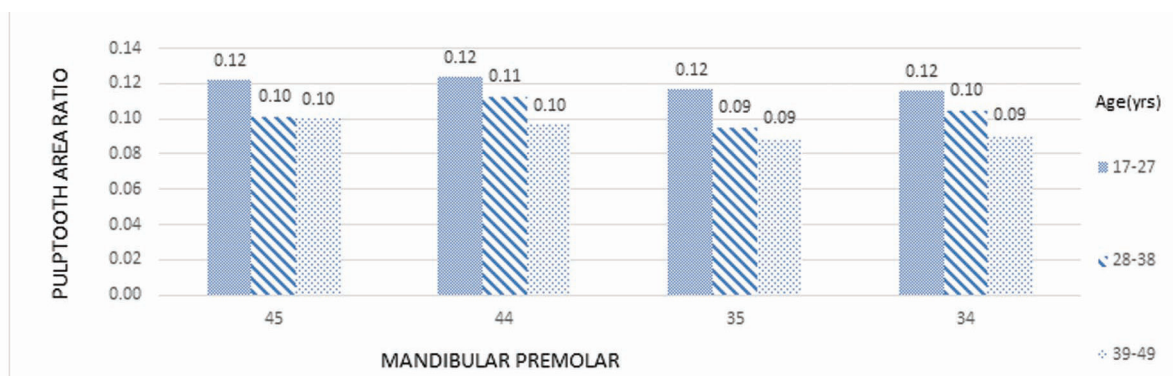

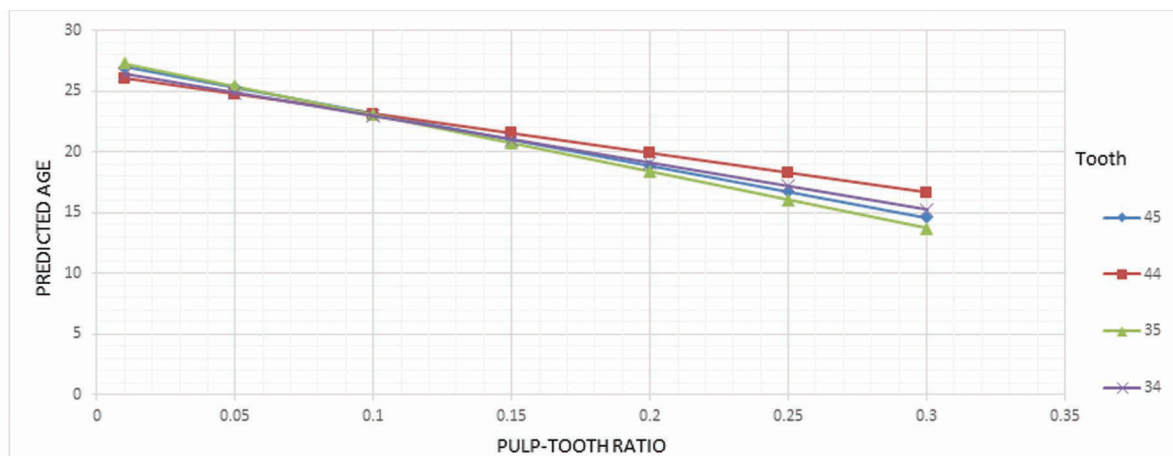Figure 2. Mean Pulp tooth area ratio in Mandibular Premolars by age groups

Figure 3. Pulp tooth area reference value for mandibular premolars with predicted age using the regression formula derived for sample population.

DISCUSSIONS

Age is an essential parameter which helps in identification of human remains in archaeological as well as forensic cases.[7] Age estimation can be done using the clinical, histological, radiological and chemical evaluation of tooth. Radiographical method being noninvasive are being popular these days. Morse et al. in 1994 used various parameters of tooth for age estimation concluding there was vertical root canal, horizontal root canal and combined canal shrinkage per year.[11] Secondary dentin formation has proven to be an age indicator in study done by Bodecker[3] which was further verified by Kvaal et al.[12] in intra oral periapical radiographs.

Paewinsky et al.[13] used orthopantomograms to study the applicability of secondary dentin formation in age estimation. Cameriere et al. further, studied the relationship between age at death and pulp tooth area ratio in digital periapical radiographs using maxillary and mandibular canines and reported high correlation between them. Likewise, the archeological studies using the same method showed high repeatability.[7] Babshet et al. in their study using the Cameriere formula based on Italian Caucasian patients found that the formula was not appropriate for Indian population and derived their own population specific formula.[14] Other studies have also reinforced in population specific equations to predict age more accurately.[1, 3, 7, 8] Hence, this study was aimed to develop regression equation for Nepalese population sample for age estimation.

In a study by Cameriere et al. in 2012,[7] regression analysis of mono radicular teeth was done. Very close correlation of pulp tooth area ratio of lower premolars with chronological age was noted. Taking this into account we decided to choose all the mandibular premolars as study sample.

A total of 392, digital OPG's were examined which showed a good intra observer agreement indicating a high reproducibility of measurements which was similar to studies by Cameriere et al.[4] and Jeevan et al.[10] in Italian and Indian samples. In our study we found that the regression equation derived from the pulp tooth area ratio for all the mandibular premolars was statistically significant (p<0.05) predictor of chronological age in Nepalese sample. These findings were in concordance with study done by Lewis et al.[8] and Afify et al.[15] using mandibular premolars in South Indian and in Egyptian population subsequently. It was found that the regression equation for 35, with R = 0.269 was better predictor of age followed by 34, 44 and 45. Study done by Lewis et al. showed 35 to be better predictor same as in our study than 45 while measurements from 34 and 44 as poor predictor justification given as distortion of images of these teeth while taking radiograph, this finding was different from our study.[8]

In the present study, decrease in the pulp tooth area ratio was found with increase in age. This finding was similar to the study done by Lewis et al. and Jeevan et al. and it well corelated with other studies which states that pulp cavity becomes narrow as age increases due to secondary dentin deposition.[8, 10,16] In our study we found mean accuracy error was between 5.65 to 6.40 years from the derived equation. Likewise, Cameriere et al. and Afify et al. in their study calculated the mean accuracy error between 4.34 to 6.02 years and ± 4.10 to 5.66 years in Spanish and in Egyptian population using mandibular premolars as single and in combination teeth consequently.[7, 15] The variations in the mean accuracy error have been noted in many studies[5, 6, 17,18] which may be attributed to factors like individual variation in tooth size, variations in patterns of secondary dentine apposition and angles between X-ray beam and film.

The derived equation was further evaluated using AR value from 0.01-0.30 where the predicted age was 15-26 years. In the present study the actual mean age of the subjects was 22.39 years and the mean accuracy error (chronological age – estimated age) was 5.65 to 6.40 years. Thus, indicating similarity in predicted age range using AR (0.01-0.30) value.

In the present study about 90% of the sample comprised from the young adult group. Hence the regression formula derived from our study would be best suitable for the estimation of young adult age groups in Nepalese population.

LIMITATIONS
Present study comprised of data from single institutions hence, data with larger sample size is recommended.

CONCLUSIONS
The results from the present study concluded that Pulp tooth area ratio can be used as tool in forensic science for age estimation of dead as well as living individual. In our study we found that Mandibular premolars and

the regression formulae obtained using the digital orthopantomograms can be used for age estimation in young adults in Nepalese population samples. However, since this study was done in lower premolars more studies using other teeth and other morphological variables with larger sample size are recommended.

Acknowledgements

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