RESEARCH ARTICLE

AGE ESTIMATION USING TOOTH/ PULP AREA RATIO IN PERMANENT MAXILLARY AND MANDIBULAR CANINES BY KVAAL'S METHOD ON DIGITAL PANORAMIC RADIOGRAPH

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ARTICLE INFO	ABSTRACT
	Background: Age estimation is an important aid for personal identification in both, living and dead. Radiography has a vital role in forensic odontology and is widely used as a non- invasive method for age estimation, which is carried out through tooth developmental stages in children and from secondary dentin deposition in adults. **Objectives:** To assess the chronological age from the morphological parameters of all the permanent canines using digital panoramic radiographs and to evaluate the applicability of Kvaal's method in local Gujarati population. **Material and method:** A cross-sectional study was undertaken on 300 digital panoramic radiographs wherein the images of all the four permanent canines were analyzed by the investigators jointly, using Adobe Acrobat professional 8.0 and Adobe Photoshop 7.0.1 software. The measurements of each canine was estimated by using Kvaal's method, and were subjected to statistical analysis, using pearson's correlation and linear regression model. **Results and Observations:** The age of participants ranged from 18 to 64 years, with mean of 28.54 ± 8.39 years. The difference in morphological variables between males and females was not significant. The Pearson's correlation coefficient in maxillary canine sshowed that except variable 'A', all the other variables had correlation with age. Similarly, in mandibular canines the variables 'T', 'B' and 'W-L' correlated significantly with age. The stepwise linear regression analysis was performed to correlate the variables with chronological age and a linear regression formula was obtained for Maxillary and Mandibular canine. The regression equation with the variable in Maxillary canine explained 3.5% of total variance ($R2 = 0.035$) with the standard error of estimate of 8.63 years and median of residuals of 2.36 years. The regression equation with the variable in Mandibular canine explained 1.9 % of total variance ($R2 = 0.019$) with the standard error of estimate of 8.7 years and median of residuals of 1.8 years. The p value <0.05 is for both, constant and W-L, which signifies, significant relationship between the parameter and age. **Conclusion:** The morphological parameters used in estimating age from Maxillary and Mandibular canines, are not good predictors of age in our study. Thus, Kvaal's method is not a reliable method for predicting age from permanent canines.

INTRODUCTION

Age estimation is an important aid for personal identification in both, living and dead. The Identification of deceased becomes difficult in decomposed bodies, natural calamities, heinous crimes or massive accidents etc (Patil *et al.,* 2014). In recent times age computation has become important for medico legal purposes especially in adoption, pedo-pornography, in deriving pension etc., depending on the available evidences like teeth and bones, age is determined (Limdiwala and Shah, 2013).

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Tooth is the most resilient, non disintegrable and durable structure of the human body when compared with bones. Each tissue of the tooth has significant characteristics for age and sex determination. The tooth morphology and tooth structure/ tissues play major role along with use of radiographic methods.The Intraoral periapical radiograph and orthopantomogram are noninvasive and good radiographs for studying tooth developmental stages in children and secondary dentin deposition in adults (Singaraju and Sharada, 2009; Priyadarshini *et al.,* 2015). The present study was conducted to assess the chronological age in young adults and middle aged individuals, based on the morphological parameters of all the permanent maxillary and mandibular canines, using digital panoramic radiographs and computer aided software program. Also, to evaluate the applicability of Kvaal's methodand to

obtain a specific formula for the local population of Gujarat and Western India.

MATERIALS AND METHOD

A cross-sectional study was undertaken on 300 digital panoramic radiographs of participants above 18 years of age. The Permission to conduct the study was obtained from Institutional Ethics committee of Sumandeep Vidyapeeth University, Vadodara with approval no. SVIEC/ON/Dent/RP/ 16017 dtd.04/08/2016 and the study completion no.SVIEC/ ON/Dent/RP/16025 dtd. 18/11/2016. Participants having completely erupted all the permanent canines and which were free from dental caries, dental anomalies and wasting diseases, were included in the study. The measurements of each canine were jointly made on digital panoramic radiograph as per Kvaal's method and using Adobe Acrobat professional 8.0 and Adobe Photoshop 7.0.1 software. Therecorded data was statistically analyzed, using Pearson's correlation coefficient and linear regression model. The probability 'p' value was p<0.05.

RESULTS AND OBSERVATIONS

The age of participants ranged from 18 to 64 years, with a mean age of 28.54 ± 8.39 years. The study had 56% of the male participants. The difference in morphological variables between males and females was not significant. The Pearson's correlation coefficient between the age and the morphological parameters in maxillary canines showed that except variable 'A', all the other variables showed correlation with age but no strong correlation. Similarly in mandibular canines the variables 'T', 'B' and 'W-L' correlated significantly with age, but there was no strong correlation (Table 1). The linear regression analysis for maxillary and mandibular canines was performed to know the significance of morphological variables for chronological age (Table 2). The probability 'p' value was significant (p <0.001). The outcome led to in obtaining the linear regression formula (Table 3).

The linear regression formula was obtained for Maxillary canine as,

Age = 78.993 + 3.776 (W-L).
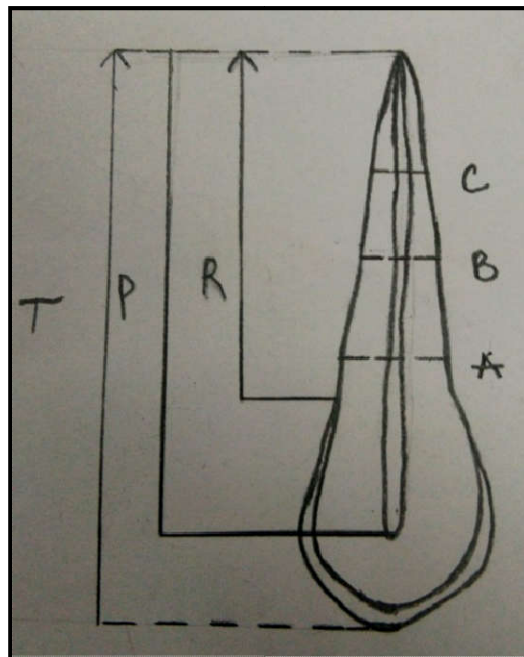
(where T - Tooth length; P - Pulp length; R- Root length; A - Root width at Cemento- enamel junction; B - Root width between A & C; C - Root width at mid-root level)

Figure 1. Schematic diagram showing tooth measurements

The regression equation with the variable explained 3.5% of total variance ($R^2 = 0.035$) with the standard error of estimate of 8.63 years and median of residuals (observed age minus predicted age) of 2.36 years. The p value <0.05 is for both constant and W-L. Similarly a linear regression formula was obtained for Mandibular canine as,

Age = 36.080 + 0.571 (W-L).

Table 1. Correlation between chronological age and morphological parameters

Parameters	Maxillary Canine (p <0.05)	Mandibular Canine (p <0.05)
Pulp length (P)	- 0.278	- 0.022
Tooth length (T)	- 0.496	- 0.264
Root length (R)	- 0.242	- 0.018
Root width at CEJ (A)	- 0.008	- 0.104
Root width between A & C (B)	- 0.249	- 0.134
Root width at Mid-root level (C)	- 0.147	0.001
Mean values of width ratios from levels B &C (W)	- 0.198	0.108
Mean values of length ratios (L)	- 0.223	- 0.112
Difference between W & L (W-L)	0.187	0.139

Table 2. Regression analysis for Maxillary and Mandibular Canines

Model		Unstandardized Coefficients		Standardized Coefficients	t	'p' value
		B	Std. Error	Beta		
Maxillary	Constant	78.993	15.312		5.159	<0.001
canine	W-L	3.776	1.150	0.187	3.284	0.001
Mandibular	Constant	36.080	3.072		11.745	<0.001
Canine	W-L	0.571	0.236	0.139	2.422	0.016

Table 3. Regression equation derived for Predicting Age from Permanent Canines

Tooth	Equation	Coefficient of determination (R2)
Maxillary canine	Age = 78.993 + 3.776 (W-L)	0.035
Mandibular canine	Age = 36.080 + 0.571 (W-L)	0.019

a. Showing measurements of tooth, root and pulp length
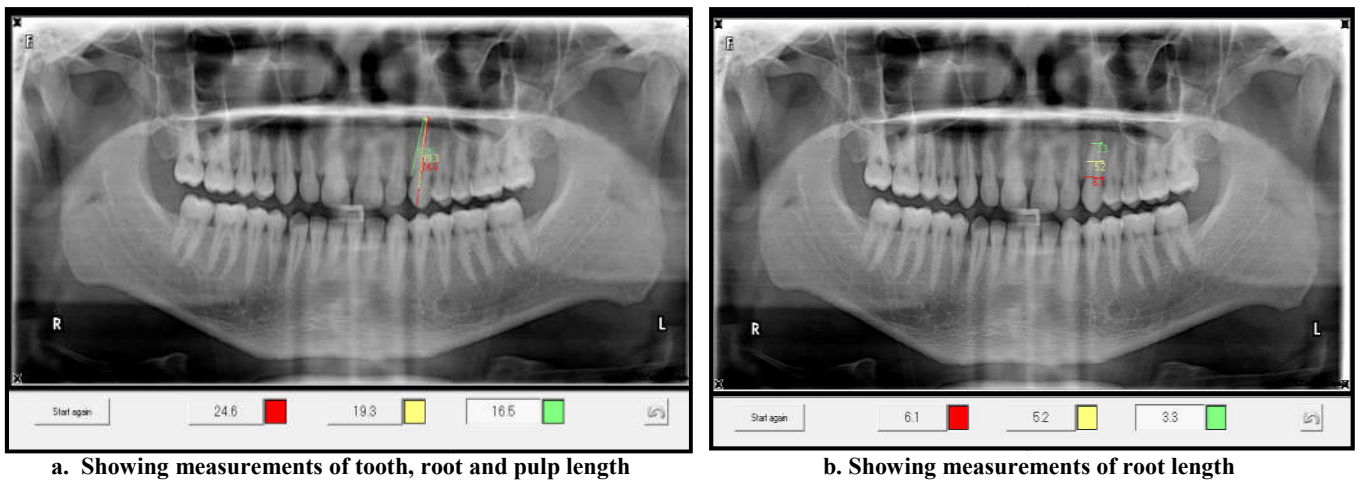
b. Showing measurements of root length

Figure 2. Measurement on permanent maxillary left canine as per Kvaal's method on
digital panoramic radiograph using computer software

a. Showing measurements of tooth, root and pulp length

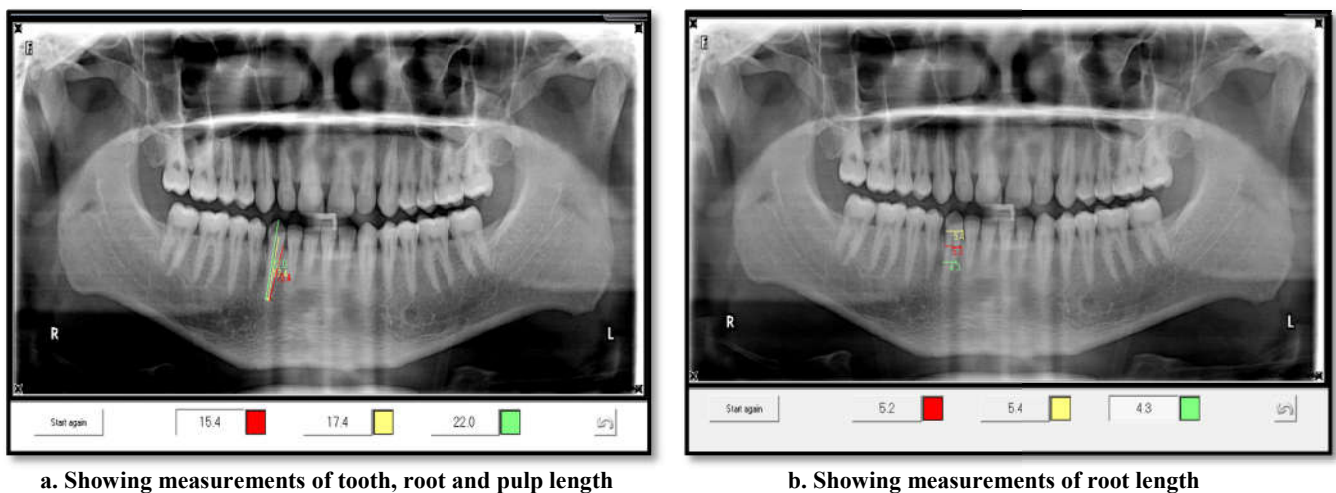b. Showing measurements of root length

Figure 3. Measurement on permanent mandibular right canine as per Kvaal's method on
digital panoramic radiograph using computer software

The regression equation with the variable explained 1.9 % of total variance ($R^2 = 0.019$) with the standard error of estimate of 8.7 years and median of residuals (observed age minus predicted age) of 1.8 years. The p value <0.05 is for both constant and W-L, which signifies, significant relationship between the morphological parameters and chronological age.

DISCUSSION

In forensic odontology, age estimation is mainly dependent on tooth structure and morphology, which are the most reliable source. The dental radiographs e.g. IOPAR and Panoramic, are routinely used in forensic science for age estimation. The morphology of tooth on radiograph can be studied focusing mainly on pulp tissue. The aging of individual causes variation in the size of pulp; may be due to apposition of secondary dentin. The measurements of various morphological parameters of tooth like pulp, tooth and root length; and Root widthat different locations are helpful to determine the age. Dr. Sigrid Kvaal in 1995, proposed the method of age estimation from tooth using intraoral periapical radiograph (IOPA). Subsequently various researchers worldwide verified the Kvaal's method either using IOPA or panoramic radiograph. Cameriere et al in 2004, studied variations in pulp-tooth ratio as an indicator for age.

The population specific formulas were also derived byresearchers, although their applicability differed geographically. Each tooth has specific characteristic feature in terms of eruption, size, shape and position. More or less every tooth has been studied and correlated for determining age. But studies on all permanent canines are very few, although canines are the teeth with largest pulp area, negligible effect of wasting diseases, good predictor for age & sex and are easy to assess (Chandramala *et al.,* 2012; Mittal *et al.,* 2016; More *et al.,* 2017). The present study was conducted to assess the chronological age from all the permanent caninesusing panoramic radiographs, in adults of Gujarat and Western India, by measuring and correlating the dimensions of tooth and pulp chamber and to evaluate the applicability/ validity of Kvaal's method in the local population. The present study had 170 males (56%) and the age of participant's ranged from 18 to 64 years with a mean age of 28.54 ± 8.39 years.The morphological variables of canines did not show any significant difference in males and females. The Pearson's correlation coefficient between the age and the morphological variables in maxillary canines showed significant correlation except in variable 'A'; whereas in mandibular canines the variables 'T', 'B' and 'W-L' correlated significantly with age. Ourthis observation matched with (Juneja *et al.,* 2014; Chandramala *et al.,* 2012; Mittal *et al.,* 2016) and did not

match with Singaraju *et al.,* 2009. The linear regression analysis for maxillary and mandibular canines was performed to know the significance of morphological variables for chronological age (p <0.001). The linear regression formula was derived for Maxillary canine as, Age = 78.993 + 3.776 (W-L), with the variable explained 3.5% of total variance (R^2 = 0.035) with the standard error of estimate of 8.63 years and median of residuals (observed age minus predicted age) of 2.36 years. Similarly, a linear regression formula was obtained for Mandibular canine as, Age = 36.080 + 0.571 (W-L), with the variable explained 1.9 % of total variance (R^2 = 0.019) with the standard error of estimate of 8.7 years and median of residuals (observed age minus predicted age) of 1.8 years. The p value <0.05 is for both constant and W-L, which signifies, significant relationship between the morphological parameters and chronological age. Ourthis observation matched with (Juneja *et al.,* 2014; Chandramala *et al.,* 2012; Mittal *et al.,* 2016) and did not match with Singaraju *et al.,* 2009. We presume that our results were definite and accurate and this may be because of larger sample size.

Conclusion

The results of our study are based on the morphological variables of maxillary and mandibular canines. Our study, thus confirms that Kvaal's method is not a reliable method for predicting age from permanent canines in population situated in Gujarat and Western India. The linear regression equation obtained in our study for maxillary and mandibular canines may be verified for age estimation in other geographical areas with larger sample size and on other single rooted teeth.

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