

Age Estimation by Kvaal's and Tooth Coronal Pulp Index by Using OPG: A Comparative Study

Dhaval Mehta^{1*} Jaideepa² Arif Awati³ Vidhi Katira⁴ Albert Ashem⁵ Hiral Ruparelia⁶

¹Professor and Head, Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

²Post Graduate Student, Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

³Post Graduate Student, Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

⁴Post Graduate Student, Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

⁵Post Graduate Student, Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

⁶Post Graduate Student, Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

ABSTRACT

Background: Aim of the study is to estimate the accuracy of age estimation by Kvaal's method and Tooth Coronal Pulp Index in a Gujarati population. A total of 240 subjects with the age group of 20-50 years were included in the present study. Panoramic radiograph were taken for each subject. For Kvaal's method, the measurements of the length and width (in mm) of six teeth were performed, whereas for TCP index, the length of tooth crown and that of coronal pulp cavity (in mm) of mandibular molars. This study clearly states that TCP ratio (± 0.5 years) is superior than Kvaal's method (± 15 years) in age estimation for Gujarat population.

Keywords: Age Estimation, Panoramic, Kvaal's, Pulp index.

INTRODUCTION

Forensic odontology is one of the most unfamiliar and fascinating branches of Dental Sciences. Age estimation constitutes an important factor in the Personal identification ¹ It is necessary not only to aid identification of the dead, but also for living individuals to clarify criminal and civil liability and social issues.² Particularly age estimation is frequently used due to incorrect birth records. In addition, the demand for age estimation is rising in some countries due to increased numbers of immigrants and refugees without valid identification documents. Dental age estimations can be made using a number of methods, which may be divided into two groups. The first, based on the emergence and formation of teeth, is used in individuals whose dental development is not complete. The second, based on age-related changes in teeth, is used in individuals whose dental development is complete.³ Most of the methods for adults cannot be used in living individuals because

they require tooth extraction. Thus, several authors have presented radiologic techniques for dental age estimation in living adults.⁴ Few are known, and all are based on one- or two-dimensional radiographic measurements of the reduction in the dental pulp cavity associated with advancing age due to secondary dentin formation. Various dental age calculation methods are described in the literature, but most of them offer a destructive approach in the form of extraction and preparation of microscopic sections of teeth, which may not be acceptable for ethical, religious, or scientific reasons.⁵ Any method used for age estimation in forensic sciences should clarify issue with significant legal and social ramifications for individuals as well as for the community. In such circumstances, a radiographic approach if used, offers a relatively nondestructive method and eliminates the need for extraction of teeth. The dental pulp is a delicate soft tissue enclosed within the confines of calcified structures, namely, dentin and enamel, and is well protected from the external tooth environment.⁶ The

Received: Jan. 18, 2017; Accepted: Mar. 17, 2017

*Correspondence Dr. Jaideepa.

Department of Oral Medicine and Radiology, Narsinhbhai Patel Dental College & Hospital, Visnagar, Gujarat, India.

Email: jaideepa131988@gmail.com

regressive changes in the pulp have also been related to age. It is a well-known fact that both, the developmental and regressive changes to the tooth can be related to chronological age. The size of the pulp decreases with age due to the deposition of the secondary dentin, and this is a continuous process that occurs throughout life.⁷

Hence dental pulp can be used as a parameter to assess the age of an individual even during later periods of life, when other methods cannot be employed. Kvaal's method is one such method, which was initially applied to intraoral periapical radiographs and very recently on digital orthopantomographs (OPGs) for estimating the age of an individual. Pulp-tooth ratio is calculated for six teeth (mandibular and maxillary) & the age is derived by using these pulp to tooth ratios in the formula; $\text{Age} = 129.8 - (316.4 \times m) (6.8 \times [W-L])$.⁸ Tooth - coronal index (TCI) using dental radiographs based on reduction in the size of the dental pulp cavity with advancing age as a result of secondary dentin deposition, has been presented. It measures correlation between the reduction of the coronal pulp cavity and the chronological age. Panoramic radiography is used to measure the coronal length and coronal pulp length. The tooth-coronal index (TCI) is computed for each tooth by using formula: $\text{TCI} = \text{TCPH} \times 100 / \text{CL}$.⁹ The present study aims to assess the accuracy of age estimation from Kvaal's and Tooth coronal pulp index using OPG & to develop regression equations that can be used in the Gujarat population.

MATERIAL AND METHOD

This study was conducted on a total of 240 patients selected from OPD, department of Oral Medicine & Radiology, NPDCH age range from 20-50 years. They were subjected to panoramic radiographs after taken written informed consent. The study population was divided into 6 groups. Group 1 – 6 from the age range from 20-50 years with an interval of 5 years. OPG of 240 patients taken on kodak 8000C digital panaromic and cephalometric system. The panoramic radiographs were chosen because most of intraoral films were exposed to reveal pathologies such as caries and inflammatory process. But with panoramic radiographs it is possible to select teeth free from pathology with a distinct pulp chamber. The

advantages of using panoramic X-ray photographs are: 1) Cutting the teeth is not necessary; 2) Panoramic X-ray is a very common dental-test, so it could be examined in a short time; 3) All the mandibular and the maxillary teeth are on one film; 4) Gross lesions (fractures, unerupted teeth) are readily visible. 5) Vertical measurements had acceptable accuracy and reproducibility when a software-based calibrated measurement tool was used. Panoramic X-ray shows a lack of detail in comparison with the intraoral radiography, especially for the anterior teeth, and the projection can only be taken at one angle. For these reasons, the posterior teeth where the pulp chamber is normally fully visible were only chosen, disregarding all the pathological specimens. The exposure parameters were set according to the patient's age and size. The patient's identification number, sex, age and date of radiographic taking were recorded. The exclusion criteria were: subjects with any developmental, endocrine or nutritional disorder and special dental diseases. Also panoramic radiographs showing impacted teeth, teeth with root canal treatment, crown restorations, broken teeth, teeth with large areas of enamel overlap between neighboring teeth, missing one of the studied teeth or unclear radiographs were excluded. For kvaals method measurements were carried out on six teeth (maxillary central and lateral incisors, maxillary second premolar, mandibular lateral incisor, mandibular canine, mandibular first premolar). The teeth were selected from either the right or left side of the jaw. And for tooth coronal pulp index 240 mandibular 1st molar teeth both right and left were taken and fully visible pulp cavity two measurements were taken, height of the crown (CH) and height of the coronal pulp cavity (CPCH). All the OPGs were collected & measured by using Kodak dental software in a millimeter scale. All the measurements were done by the single examiner in order to eliminate the inter observer bias. Descriptive Paired t-test was used to compare these values in males & females. Multivariate linear Regression analysis was used to estimate Age. The analysis were performed by using the SPSS 22 .

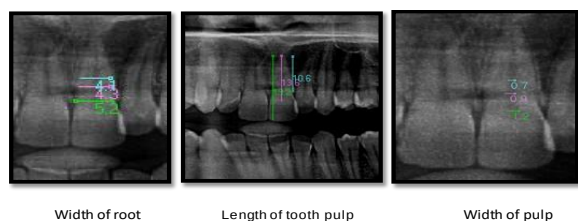


Fig 1: Kvaals method measurements.



ig 2: TPI method measurements

RESULTS

The paired t-test to evaluate potential observer error revealed no statistically significant intra- and inter-observer differences between the paired sets of measurements carried out on the re-examined panoramic radiographs ($p > 0.05$). Descriptive analysis of the studied subjects by means of age ($n = 240$) are summarized in Table 1 and graph 1. The mean $\pm$ SD of TPI R is 29.96 ± 3.93 and TPI L is 31.64 ± 3.66 in age range 21-

25 years. But as the age increases it goes on decreasing TPI R is 25.81 ± 4.10 and TPI L is 26.51 ± 3.85 in age range 46-50 years. Left Side TPI is more when compared to right Side.

$$Y = B + aX$$

$$Y = B + a_1 * TCPR + a_2 * TCPL$$

For combined:

$$Y = 66.73 + (-0.573 * TCPR) + (-0.588 * TCPL)$$

By estimating with this equation we are getting an error of ± 10 years in all the age group.

So newer formulas according to age groups were obtained.

$$GR - 1 - Y = 20.47 + (0.057 * TCPR) + (0.026 * TCPL)$$

$$GR - 2 - Y = 24.68 + (-0.055 * TCPR) + (0.163 * TCPL)$$

$$GR - 3 - Y = 30.16 + 0.155 * TCPR + (-0.048 * TCPL)$$

$$GR - 4 - y = 40.01 + (-0.092 * TCPL)$$

$$GR - 5 - Y = 36.77 + 0.160 * TCPR + 0.077 * TCPL$$

$$GR - 6 - Y = 47.45 + (-0.020 * TCPR) + 0.040 * TCPL$$

With these formulas the age at respective age group was determined at an accuracy of ± 0.5 years

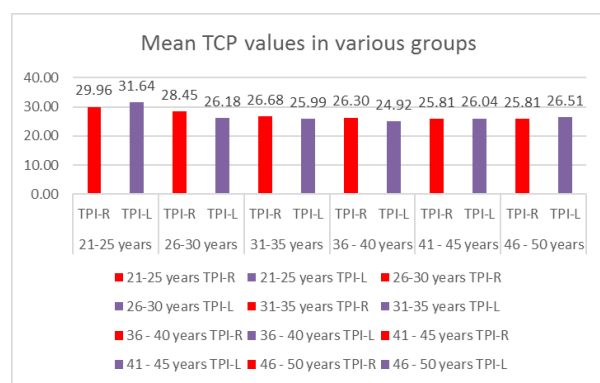
Table 1. Mean values of tooth pulp index according to age.

Group	Parameter	Mean	Std. Deviation
I. 21-25 years	TPI-R	29.96	3.93
	TPI-L	31.64	3.66
II. 26-30 years	TPI-R	28.45	2.98
	TPI-L	26.18	3.56
III. 31-35 years	TPI-R	26.68	3.12
	TPI-L	25.99	2.83
IV. 36 - 40 years	TPI-R	26.30	4.60
	TPI-L	24.92	2.89
V. 41 - 45 years	TPI-R	25.81	4.10
	TPI-L	26.04	2.77
VI. 46 - 50 years	TPI-R	25.81	4.10
	TPI-L	26.51	3.85

Table 2. Kvaal's method in Gujarat population.

Tooth	Regression formula	R	Sig
Maxillary central incisor	$Y = 82.95 + 0.890 * T + (-3.09 * R) + (-9.252 * A) + 7.428 * C$	0.738	0.003
Maxillary lateral incisor	$Y = 70.55 + 1.560 * T + (-3.40 * P) + (-1.759 * R) + 6.291 * C$	0.816	0.000
Maxillary 2 nd premolar	$Y = 108.32 + (-2.323 * P) + (-1.324 * R) + (-6.329 * A)$	0.580	0.000
Mandibular lateral incisor	$Y = 49.123 + (-2.417 * T) + 4.640 * P + (-2.228 * R) + 19.152 * B + (-20.840 * C)$	0.642	0.000
Mandibular canine	$Y = 96.62 + (-2.696 * T)$	0.672	0.000
Mandibular 1 st premolar	$Y = 89.65 + (-2.44 * P) + (-1.58 * R) + (-4.71 * A)$	0.974	0.000

Graph 1: mean values of tooth pulp index according to age.



With these equations the estimated age is varying with age range of ± 15 years. We have tried separate formulas for individual age group which also resulted in variation of ± 6 years. So kvaals method is not applicable for Gujarat population.

DISCUSSION

Forensic odontologist often confronted with the problem of determining the age of unknown bodies and living persons. Teeth has played a important role in estimating chronological age of individuals because of low variability and high accuracy than other methods. In the present study two adult age estimation methods were evaluated for their accuracy in age estimation. Kvaals method showed a discrepancy of ± 15 years, whereas TCP ratio showed a discrepancy of ± 0.5 years in Gujarat population. A new formula was designed for accurate age estimation. Hence TCP ratio can be considered as the accurate method for age estimation in Gujarat population Igbigbi et al. measured the height (mm) of the crown (CH = Coronal Height) and the height (mm) of the coronal pulp cavity (CPCH = Coronal pulp cavity height) of

premolars and molars of 134 adult Malawians (77 males, 57 females) aged 20 80 years from dental radiographs. The Tooth-Coronal Index (TCI) was computed for each tooth and regressed on real age. They obtained equations estimation of age with an error of ± 5 years in their studied population, the molar equation estimated age better for males while the premolar equation was for female and combined samples. The results of the present study were similar to the previous researches like Nathalie et al., H. O erbudak et al., Madhu sastrha et al. where the discrepancy is high about ± 15 years in estimation of age by kvaal's method. One of the study done in Italy by Drusini et al. [10]; Drusini [11]; Zadzinska et al. [12]; in India by Shrestha [13]; in Egypt by Khattab et al. [14] and in Western Australia by Karkhanis et al. [15]. They stated that sex of individual appears to have no significant influence on age estimation, so that sex specific formulae are not necessary for age estimation in specimens of unknown sex. On the other hand this result is on contrary to that of Agematsu et al. [16] in Japan; Igbigbi and Nyirenda [17] in Malawi; who mentioned that gender has a significant influence on age estimation using TCI and hence there is need for sex - specific formulae in the sampled population. In addition. Furthermore; to the best of our knowledge, this is the only work that studied the effect of side (either right or left teeth) on TCI. There is significant difference between right and left teeth as regard TCI. This may be due to developmental or morphological changes or the accuracy of radiographs. Kvaal et al. [13] applied his study on left side and if due to tooth positioning, tilting or overlapping, insufficient tooth information was available, the corresponding tooth of right side was measured. In the original method of Kvaal et al. periapical radiographs were used and the measurements were carried out manually using a

stereomicroscope. The standard errors of the estimates ranged from 8.6 to 11.5 years, and the determination coefficients for the estimation from 0.56 to 0.76. The application of Kvaal et al.'s method to panoramic radiographs has yielded varied results.

CONCLUSION

Age estimation in adult population is a challenging aspect in forensic odontology. This study clearly states that TCP ratio (± 0.5 years) is superior than Kvaal's method (± 15 years) in age estimation for Gujarat population. TCI is a precise, non-invasive, not time consuming; not requires highly specialized equipment and applicable to both living and dead individuals. Hence it provides a baseline data for further researches in this area of interest.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Ranjdar M Talabani et al. Age estimation using lower permanent first molar on a panoramic radiograph: a digital image analysis. 2016. vol 7. issue 2. 158-162.
2. Pooja S. Rajpal et al. Age estimation using intraoral periapical radiographs. 2016. vol 8. (1). 6-11.
3. El Morsi DA et al. Tooth Coronal Pulp Index as a Tool for Age Estimation in Egyptian Population. 2015. vol 3. issue 2. 1-8.
4. Hu'meyra O'zge Erbudak et al. Application of Kvaal et al.'s age estimation method to panoramic radiographs from Turkish individuals. 219 (2012). 141-146.
5. Piyush G. Limdiwala et al. Age estimation by using dental radiographs. 2013. vol 5. (2). 118-122.
6. Smrithi D Veera Coronal pulp biomarker: A lesser known age estimation modality 2015. vol 26. (4). 398-404.
7. S.I. Kvaal, K.M. Kolltveit, I.O. Thomsen, T. Solheim, Age estimation of adults from dental radiographs, *Forensic Sci. Int.* 74 (1995) 175-185.
8. Sharma R, Srivastava A. Radiographic evaluation of dental age of adults using Kvaal's method. *Journal of forensic dental sciences.* 2010 Jan 1;2(1):22.
9. Igbigbi PS, Nyirenda SK. Age estimation of Malawian adults from dental radiographs. *West African journal of medicine.* 2005 Oct;24(4):329-33.
10. Drusini AG (1993) Age Estimation from Teeth Using Soft X-Ray Findings. *Anthrop Anz* 51: 41-6.
11. Drusini AG (2008) The Coronal Pulp Cavity Index: A Forensic Tool for Age Determination in Human Adults. *Cuad Med Forense* 14: 235-49.
12. Zadinska E, Drusini AG, Carrara N (2000) The Comparison Between Two Age Estimation Methods Based on Human Teeth. *Przegląd Antropologiczny – Anthropological Review* 63: 95-101.
13. S.I. Kvaal, K.M. Kolltveit, I.O. Thomsen, T. Solheim, Age estimation of adults from dental radiographs, *Forensic Sci. Int.* 74 (1995) 175-185.
14. Khattab NAF, Marzouk HM, AbdelWahab TM (2013) Application of Tooth Coronal Index for Age Estimation Among Adult Egyptians. *Schoolary Res* 15. 40.
15. Karkhanis S, Mack P, Franklin D (2013) Age Estimation Standards for a Western Australian Population Using the Coronal Pulp Cavity Index. *Forensic Sci Int* 231: 412e1-6.
16. Agematsu H, Someda H, Hashimoto M, Matsunaga S, Abe S, et al. (2010) Three Dimensional Observation of Decrease in Pulp Cavity Volume Using Micro – CT: Age Related Change. *Bull Tokyo Dent Coll* 51: 1-6.

17. Igbibi PS, Nyirenda SK (2005) Age Estimation of Malawian Adults from Dental Radiographs.

WAJM 24: 329-33.