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Age Estimation in an Iranian Population Based on Pulp/Tooth Area Ratio (PTR)

[1]Mahkameh Moshfeghi, [2]Morteza Ghojazadeh, [3]Zahra Khalili Sadrabad,
[4]Mohammad Mostafa Shadkar and [5]Zahra Shadkar
[1]Department of Orofacial Radiology, Faculty of Dentistry,
Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Department of Physiology, Faculty of Medicine,
[3]Department of Pediatric Dentistry, Faculty of Dentistry,
Tabriz University of Medical Sciences, Tabriz, Iran
[4]Dentist, Tabriz, Iran
[5]Dentist, Tehran, Iran

Abstract: Estimation of age in individuals has received considerable attention in the forensic literature. Previous studies on age prediction have focused on histological parameters which are not feasible in living adults. Using dental radiographs to measure the amount of secondary dentin deposition seems to be appropriate for age estimation. The aim of the present study was to estimate the age of an Iranian population using panoramic radiographs. Panoramic radiographs of 112 Iranian patients, aged 20-70 were selected randomly and their pulp/tooth ratios were calculated. The sample population was divided into two groups of 48 and 64 subjects. Iranian formula was calculated for the first group and was applied to the second group. E, A, C and B parameters, related to the measurement of canine pulp area were shown to be capable of estimating age (E: $r = -0.48$, $p<0.001$) (A: $r = -0.67$, $p<0.001$) (C: $r = -0.61$, $p<0.001$) (B: $r = -0.61$, $p<0.001$). In addition in relation to the first premolar, A, C and B parameters were predictive for age (A: $r = -0.34$, $p = 0.01$) (C: $r = -0.53$, $p<0.001$) (B: $r = -0.39$, $p = 0.006$). Radiographic parameters of lateral incisor were unable to predict age.

Key words: Age estimation, secondary dentin, panoramic radiography, digital radiography, pulp

INTRODUCTION

Several methods for estimating the age of people, older than 20 years of age are used in forensic research with different results, however, most methods are useful only for dead bodies.

In 1889, Lacassagne was the first one to use dental changes in order to estimate age during adulthood (Johnson, 1976). Bodecker (1925) showed that dentin deposition has a close relationship with age. During tooth development, secondary dentin formation begins after dentinogenesis and odontoblasts that cover the pulp cavity deposit secondary dentin layers along the pulp chamber wall continuously (Berkovitz *et al*., 1992). Having developed secondary dentin formation, pulp chamber will decrease in size (Gustafson, 1950; Johanson, 1971; Morse, 1991; Solheim, 1992).

Gustafson (1950) designed the first scientific method of age estimation. Six characteristics of teeth, including secondary dentin deposition, attrition, gingival recession, cementum formation, root resorption and root translucency were the major parameters for investigation in this study. Using this method required tooth extraction and so it was an invasive solution.

Kvaal *et al*. (1995) measured secondary dentin deposition, using dental radiographs and found a relationship between such measured parameters and the age of samples. Different results have been achieved using Kvaal *et al*. (1995)'s Method. The aim of the present study was to calculate an Iranian age estimation formula and verify whether the population-specific formula enhanced age prediction.

MATERIALS AND METHODS

A total of 112 Iranian adults, without any specific systemic disease whose age ranged between 20 and 70 and referred to the Oral Radiology Department were included in this cross-sectional study. Digital panoramic radiographs were collected and randomly divided into two population groups of 48 and 64. Then, the specimens were classified into different age groups.

Corresponding Author: Zahra Khalili Sadrabad, Department of Pediatric Dentistry, Faculty of Dentistry,
Tabriz University of Medical Sciences, Tabriz, Iran

The selected teeth were completely exposed to the mouth and the roots were fully formed. Rotated and impacted teeth and teeth with pathologic problems such as caries and occlusal wear or dental treatments were excluded.

Although, the primary method of Kvaal *et al.* (1995) included the analysis of six teeth (three teeth in the maxilla and three teeth in the mandible) due to the superimposition of adjacent tissues only three mandibular teeth (lateral incisor, canine, first premolar) were examined and evaluated in this study.

In all the radiographs, the following items were measured by a single observer in blind condition (Fig. 1):

- T = Maximum Tooth length
- P = Maximum Pulp length
- R = Root length on the mesial aspect from CEJ to apex
- Root and pulp width at CEJ (level A)
- Root and pulp width at mid-root (level C)
- Root and pulp width in the middle of CEJ and at mid-root (level B)

To compensate differences in magnification and angulation in panoramic radiographs, we used these ratios:

- D = Pulp length/root length
- E = Pulp length/tooth length
- A, C, B = Pulp width/root width at three levels (A, C, B)

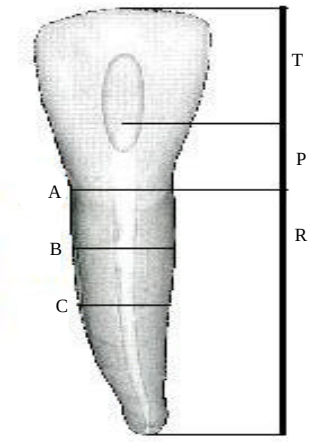

Fig. 1: Parameters measured on the panoramic radiographs according to Kvaal *et al.* (1995): T = Maximum Tooth length; R = Root length on the mesial surface; P = Maximum Pulp length; A = Root and pulp width at CEJ; B = Root and pulp width in the middle of CEJ and midroot; C = Root and pulp width in midroot

For the measurement of each item, we selected two points on the tooth and measured the distance between them in pixels with the use of Photoshop Software 2007 to achieve as precise results as possible.

The special regression equation for Iranian society was obtained from the radiographs of the first group. This equation was used on the samples of second group by replacing the amounts of A, B, C, D and E parameters gained from samples of the control group in the new Iranian formulas and the results were compared with the results reported by Kvaal *et al.* (1995) to see whether the special equation for a society can improve the age estimation capability. SPSS 16 Statistical Software was used to analyze the radiographic data. The $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Forty-eight radiographic samples were evaluated to obtain a regression formula. The mean age of the patients was 36.54±13.37 years with an range of 20-64 (Table 1).

Pearson's correlation coefficient showed that the correlation between age and radiographic parameters of lateral incisor was not statistically significant (E: $r = -0.26$, $p = 0.07$) (D: $r = -0.20$, $p = 0.15$) (A: $r = -0.28$, $p = 0.05$) (C: $r = -0.22$, $p = 0.12$) (B: $r = -0.21$, $p = 0.13$). Pearson's correlation coefficient showed a strong inverse relationship between age and A, C and B parameters of canine (E: $r = -0.48$, $p<0.001$) (D: $r = -0.16$, $p = 0.25$) (A: $r = -0.67$, $p<0.001$) (C: $r = -0.61$, $p<0.001$) (B: $r = -0.61$, $p<0.001$). The values related to the first premolar were: (E: $r = -0.18$, $p = 0.21$) (D: $r = -0.19$, $p = 0.18$) (A: $r = -0.34$, $p = 0.01$) (C: $r = -0.53$, $p<0.001$) (B: $r = -0.39$, $p = 0.006$). Therefore, A, C, B and E parameters, related to the measurement of canine pulp area and A, C and B parameters of the first premolar could be used to predict age. Radiographic parameters of lateral incisor did not assist in predicting age.

The regression formulas related to the canine parameters are:

$$\text{Age} = 71.61\text{-}50.95\ E,\ 62.44\text{-}202.52\ A,\ 54.02\text{-}137.54\ C,\ 56.01\text{-}137.58\ B$$

The regression formulas related to the first premolar parameters are:

$$\text{Age} = 52.39\text{-}112.26\ A,\ 48.88\text{-}112.40\ C,\ 49.28\text{-}83.51\ B$$

Table 1: Age distribution of the individuals chosen for the OPG measurements

Age (years)	No. of OPGs
20-30	23 (47.9%)
30-40	7(14.6%)
40-50	7(14.6%)
50-60	9(18.8%)
>60	2(4.2%)

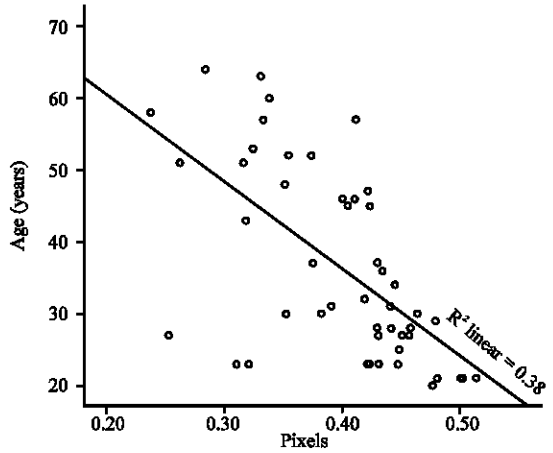

Fig. 2: Plots between the correlation of the average of A, B, C, D, E parameters in canine and the age of the individuals

The results also showed a strong inverse correlation coefficient between age and the average of parameters measured in canine ($r = -0.61$, $p<0.001$) (Fig. 2). This correlation was weak in lateral incisor ($r = -0.33$, $p = 0.01$) (Fig. 3) and the first premolar ($r = -0.31$, $p = 0.015$) (Fig. 4). There was a strong correlation coefficient between age and the combination of the average of parameters in canine and A parameter of lateral incisor ($r = -0.81$, $p<0.001$). In addition, the relationship between age and the combination of the average of parameters in canine and C parameter of lateral incisor was strong ($r = -0.82$, $p<0.001$). This correlation was also strong when we used the combination of the average of parameters in canine and B parameter of lateral incisor ($r = -0.79$, $p<0.001$).

The correlation coefficient between age and the combination of the average of the parameters of canine and the average of the parameters of lateral incisor was strong ($r = -0.78$, $p<0.001$). The evaluation of regression equations with the use of the samples of the second group showed correlation coefficients of -0.36 for the lateral incisor, -0.66 for canine and -0.54 for the first premolar. Several anatomical structures can be used to estimate age. The advantage of using teeth is that they are more resistant to change and can be easily evaluated with clinical and radiographic methods. Evaluating pulp/tooth area ratio is an indirect way of measuring the amount of secondary dentin deposition.

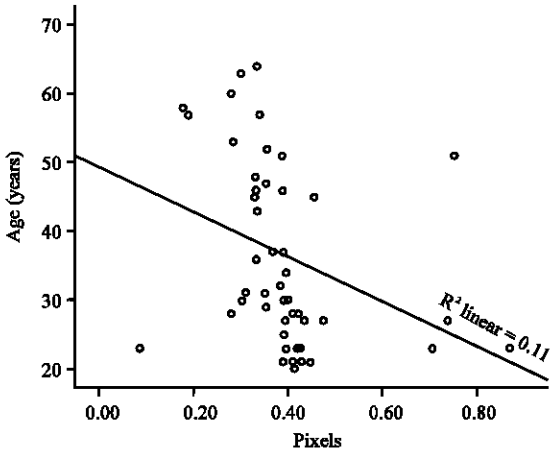

Fig. 3: Plots between the correlation of the average of A, B, C, D, E parameters in lateral incisor and the age of the individuals

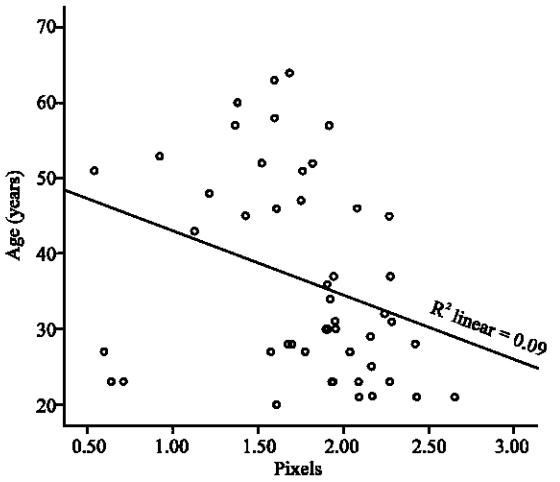

Fig. 4: Plots between the correlation of the average of A, B, C, D, E parameters in the first premolar and the age of the individuals

Different studies have shown differences in the relationship between the measured parameters of pulp area and age. A study by Cameriere *et al.* (2007) showed that using canine periapical radiographs is an appropriate way of age estimation. A study by Bosman *et al.* (2005) indicated no significant difference between the real age of individuals and the estimated age with the use of Kvaal *et al.* (1995)'s Method on panoramic radiographs. In sharp contrast with these studies and similar ones, some studies have yielded completely different results. Prapanpoch *et al.* (1992) did not find any significant relationship between age and parameters of pulp area and recommended that these measurements should not be used as a reliable method of age estimation. In

addition, Schmeling *et al.* (2007) showed that evaluating only dental parameters (for example, only dentin translucency or only secondary dentin deposition) can lead to large errors in age estimation and Meinl *et al.* (2007) showed that Kvaal *et al.* (1995)'s formula underestimated the age of Austrian samples. In the present study, the results showed that using canine parameters and also the average of them can be an appropriate method to estimate age, however, this did not apply to lateral incisor. The first premolar was more reliable than lateral incisor and less reliable than canine in age estimation. Furthermore, the combination of parameters of canine and lateral incisor might be used.

Various studies have shown the efficacy of panoramic radiographs in age prediction (Bosman *et al.*, 2005), however, accuracy of age estimation depends on the accuracy of measurements and quality of panoramic radiographs. We tried to reduce the errors due to the technique of radiography by calculating the ratios of distances.

Factors such as teeth distortion in panoramic radiographs due to the incorrect positioning of the patient can affect the accuracy of measurements. A group of researchers argue that using digital radiographs is not appropriate because it is difficult to indicate the desired points on the display screen. This limitation can be one of the reasons of the low correlation between age and some of the measured parameters. The present study showed that A, B and C parameters (parameters of pulp width) are more useful than D and E parameters (parameters of pulp length), therefore, it seems that the pulp chamber length can be more affected by several individual factors such as chewing pattern.

Some researchers have recommended that using specific formula for each gender will improve the capability of age estimation (Paewinsky *et al.*, 2005). A group of researchers concluded that the best results will be obtained by using specific formula for each population (Someda *et al.*, 2009). Some others have shown that the same equation can be used for different populations (Ubelaker and Parra, 2008). Babshet *et al.* (2010) and Cameriere *et al.* (2009) indicated that calculating a specific regression equation for a special society cannot improve the ability of age estimation.

A study by Landa *et al.* (2009) showed that parameters measured on radiographs have a weak correlation with age and applying Kvaal *et al.* (1995)'s method on panoramic radiographs is not appropriate.

The present study showed that using a specific regression equation for the Iranian society can not improve age estimation in comparison with Kvaal *et al.* (1995)'s equation and some factors such as different patterns of secondary dentin deposition in the Iranian society seem to be the reason.

CONCLUSION

Researchers concluded that canine tooth parameters and also the average of these parameters can appropriately be used for age estimation in Iranians and the width of pulp can be more useful than the length.

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