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Original communication

Digitized morphometric analysis of dental pulp of permanent mandibular second molar for age estimation of Davangere population

Nerella Narendra Kumar*, Mamatha Gowda Panchaksharappa [a], Rajeshwari G. Annigeri [b]

Department of Oral Medicine and Radiology, College of Dental Sciences, Davangere, Karnataka 577004, India

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ABSTRACT

Objective: The aim of the present study is to estimate the age of Davangere population by evaluating the pulp to tooth area ratio (PTR) by using digitized intraoral periapical radiographs of permanent mandibular second molar.

Methods: 400 intraoral periapical radiograph (IOPA) of permanent mandibular 2nd molar of both the sexes aged 14–60 years were used. Digital camera was used to image the radiographs. Images were computed and PTR was calculated by AUTOCAD software. Intra and Inter observer variability was also assessed. Regression analysis was used to estimate the age of an individual by taking PTR as dependent variable.

Results: The mean PTR of males and females was 0.10 ± 0.02 and 0.09 ± 0.02 respectively. Negative correlation was observed, when age was compared with PTR {r = −0.441, −0.406 & −0.419 among males, females and total subjects ($p < 0.001$)}. Regression analysis showed a Standard Error of Estimate (SEE) of 12 years. The Kappa coefficient value for the intra and inter examiner variability was 0.85 & 0.83 respectively.

Conclusion: Our results showed that permanent mandibular 2nd molar can be taken as an index tooth for estimating the age of the adults using digitized periapical radiograph and AUTOCAD software. Also high differences were observed between estimated and chronological age of 12 years which is not in the acceptable range. But it provides a new window for research in the forensic sciences in estimating the adult age.

1. Introduction

As we entered a new millennium, society is faced with fresh challenges in every conceivable area. Despite leaps in modern technology, medical breakthroughs and the geographical changes that the last century has brought, crime still persists in all aspects of our lives. By identifying the victims of crime through dental records, dentists assist those involved in crime investigation.[1] Identification is the establishment of a person's individuality. Age is one of the essential factors in establishing the identity of a person.[2] The need for the precise and reliable method to estimate age, particularly adult age, has become increasingly important.[3]

Age estimation helps in both civil and criminal cases such as kidnapping, rape, marriage, employment, identification, senior citizen concession, retirement benefits, in old age pension cases. Developmental indicators most commonly used for this purpose are bone maturation, secondary sex characteristics, height and weight. More recently, the dental maturation indicator system has gained impetus as a valuable index for age estimation.[4]

Teeth, the hardest structures in the body can act as a biomarker of aging. The reasons for this are they remain intact even when other components of the skeleton have disintegrated and are known to have highly resistant to different external influences as well as mechanical, chemical and thermal insults. Also, it has been further observed that the incremental pattern of tooth development or formation is not markedly affected by diseases, drug intake, endocrine status etc. as compared to bone mineralization, making them the favorite tissue in forensic and archaeological investigations.[5–7]

* Corresponding author. Department of Oral Medicine and Radiology, Narayana Dental College and Hospital, Nellore, Andhra Pradesh 524003, India. Tel.: +91 9964806228, +91 9866904885.

E-mail addresses: nerellanarendra@gmail.com (N.N. Kumar), dr_gmamatha@rediffmail.com (M.G. Panchaksharappa), rajeshwariannigeri@rediffmail.com (R.G. Annigeri).

[a] Tel.: +91 9449748615.

[b] Tel.: +91 08192 231285.

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Various modalities for dental age estimation include morphological, histological, biochemical and radiographic methods. Morphologic and histological changes studied are attrition, secondary dentin deposition, recession of the gingiva, cementum apposition, root dentin transparency and root resorption.[8] But major drawbacks of these methods require extraction and microscopic preparation which may not be acceptable for cultural, religious or scientific reasons. Radiographic evaluation of teeth requires neither tooth extraction nor sectioning. Therefore, techniques are being developed for age estimation in living individuals which mostly rely on radiological imaging of teeth.[9,10]

The study of morphological parameters of teeth on dental radiographs of adults is more reliable than other methods of age estimation.[3] One such method is assessment of **pulp to tooth area ratio** which is an indirect quantification of secondary dentin deposition which is clearly seen on radiographs with advancing age that has significant correlation with age.[11,12] However, advanced techniques like digitalization of panoramic radiographs, computer assisted image analysis, radiovisiography and volumetric analysis by cone beam computed tomography can be utilized, which offer advantages like elimination of bias inherent in observers' subjectivity and improved reliability, accuracy and precision.[3]

Most of the radiographic methods of age estimation have utilized anterior teeth and second premolars and only few studies have been reported where molar teeth have been utilized. Due to morphological stability, prolonged retention in oral cavity and easy accessible for radiographic procedure, permanent mandibular second molar is selected for assessment. Thus, the aim of the present study is to estimate age of Davangere population by evaluating the pulp to tooth area ratio using digitized intraoral periapical radiographs of permanent mandibular second molar.

2. Material and methods

The present prospective study was based on 400 digitized intraoral periapical radiographs of permanent mandibular 2nd molar taken from the individuals in the age range of 14–60 years. The subjects for this study were taken from the out patients that attended the Department of Oral Medicine and Radiology, College of Dental sciences, Davangere during the period, October 2013 to August 2014 after obtaining written informed consent. Protocol of the study was approved by the Ethical committee, College of Dental Sciences, Davangere.

Subjects were selected for the present study with the inclusion criteria of subjects with known date of birth and subjects willing to participate in the study with no obvious dental disease and developmental disorders. Exclusion criteria were: impacted teeth, teeth with root canal treatment, teeth with large area of overlap between neighboring teeth, teeth with vestibular radio opaque fillings visible on radiographs, severe regression changes, teeth which are affected by pulpal calcification, developmental anomalies of teeth and subjects who are pregnant.

A total of 430 radiographs were assessed for age estimation. The pulp chamber was not able to delineate properly in 30 radiographs and hence they were discarded. Thus, a total of 400 radiographs were analyzed.

All the subjects were divided into five groups; each group consisting of 80 subjects and this 80 consists of 40 subjects from each gender based on their chronological age: group I (14–20 years); group II (21–30 years); group III (31–40years); group IV (41–50 years) and group V (51–60 years). Kvaal et al. (1995) stated that there were no significant differences between permanent teeth from the left or right side of the jaw.[9] Consequently in the present study teeth were chosen either from the right or left side whichever were best suited for the measurement.

All the subjects underwent routine clinical examination and the relevant data was entered in the structured proforma. Patients' birth dates were noted after analyzing their specific identity proofs to record the chronological age. The intraoral periapical radiographs were taken by paralleling technique using X-ray equipment (Gendex Oralix with 65 KVP, 7.5 mA and exposure time ranges from 0.50 to 0.64 ms) with manual processing after taking all necessary protective measures. According to Koltveit et al.,[13] each radiograph was mounted on X-ray illuminating table and viewed through a digital camera (Sony DSC-WX 150, 18.2 Mega Pixel). Then the radiographic images were converted to a JPEG image file. These digitized images were imported to Adobe Photoshop CS image editing software program wherein the teeth long axis were aligned vertically using the measure tool. A number of horizontal reference lines are marked at specific intervals along the length of the tooth, after which the images were once again saved as high resolution JPEG files. The digitized images were processed using computer aided drafting program (AUTOCAD 2012). Using the Spline tool provided in this program and the outline of the tooth and its pulp chamber were traced on the digitized image. The tracing of the images was done using twenty points for each tooth outline and ten points for the pulp chamber. After completion of the tracing, the program displayed the area of the tooth and its pulp chamber respectively. Then the pulp/tooth area ratio of the tooth was calculated (Fig. 1).

To test the intra examiner reproducibility, a random sample of forty digitized images were re-examined after an interval of 4 weeks. To test the inter examiner reproducibility, a random sample of forty digitized images were re-examined by the second author.

3. Statistical analysis

Statistical analysis was performed using Statistical Program for Social Sciences (SPSS), Version 16. Unpaired t-test was used to assess the difference between PTR of males and females. Pearson's correlation test was used to assess the correlation between the age and PTR. To predict the age of an individual simple linear regression analysis was used. To assess the Intra and Inter observer variability, Kappa statistics was used. p value of ≤ 0.05 was considered as significant.

4. Results

A total of 400 subjects were included in the present study, among which 200 individuals of each sex in the age range of 14–60 years were included.

The mean PTR of subjects in each group was shown in Table 1. The mean PTR of males and females were 0.10 ± 0.02 and 0.09 ± 0.02, unpaired t-test revealed a p value of 0.008 which showed a statistically significant difference suggesting that gender have an effect on the morphological variable (PTR) (Table 2).

To assess the nature and degree of correlation of morphological variable i.e., PTR with actual age, Pearson's correlation coefficient was employed. (Table 3) It was found that PTR was significantly correlated with age and has an inverse relationship with each other. Scattered plot showing relationship between PTR and age of females, males and combined sample was presented in Fig. 2a, b & c respectively.

Linear Regression analysis was done where the age was taken as dependent variable and PTR as an independent variable. Linear regression equation for estimation of age and Standard Error of Estimate (SEE) was presented in Table 4. As there was statistically significant difference of PTR between males and females ($p = 0.008$), separate prediction equation for age estimation was derived for males and females separately. SEE predicts the