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Review Article

Monoradicular Teeth – Aid in Forensics for Age Estimation: A Short Review

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Abstract

Age is one of the essential factors in establishing the identity of the person. Although several body parts can be used for age estimation, the poor condition of the remains, often prevent their use. For this reason teeth are most frequently used for identification and age estimation, as teeth are the most durable and resilient parts of the skeleton. Incisors and canines of both arches and premolars of lower arch and 2nd premolar of upper arch are monoradicular teeth, the geometric factors of panoramic projection make the tracing of monoradicular teeth easier than that of biradicular/triradicular teeth. And these teeth are less likely to suffer wear and tear as a result of particular work than other anterior teeth. Recently non-invasive radiographic techniques have been developed for measurements of the reduction in the dental pulp cavity associated with advancing age due to secondary dentin formation. This reduction in pulp chamber was correlated with chronological age and regression equations were derived to estimate the age. The relationship between age and age-related changes in the pulp/tooth area ratio showed significant correlation to the chronological age when monoradicular teeth are used. This review highlights the significant role of monoradicular teeth in age estimation.

Keywords: Forensic Science; Single Rooted Teeth; Pulp/Tooth Area; Age Estimation; Panoramic Radiographs

Introduction

Forensic odontology has played a key role in identification of persons in mass disasters (aviation, earthquakes, Tsunamis), in crime investigation, in ethnic studies, and in identification of decomposed and disfigured bodies like that of drowned persons, fire victims, and victims of motor vehicle accidents. The need for identification of an unknown person can be social, emotional and legal [1].

Identification by means of distinctive features of dentition is an important arena of the branch of forensic odontology. Dentition can now be employed with reliability in identification of an unknown body or remains. Identification of an individual, living or dead, is based on the theory that all individuals are unique. All humans are born with anomalies or acquire artifacts. An anomaly is a unique congenital condition (eg, mesiodens, missing lateral incisor, hemangiomas). An artifact is a man-made alteration (dental restoration, extracted tooth, scar, and tattoo). Due to the lack of comprehensive fingerprint database, human dentition is considered as analog to the finger print, which is unique to each individual.

Available dental evidence can be soft tissue structures or hard tissue structures. Soft tissue structures commonly used for identification are cheiloscopy(lip print) and rugoscopy (palatal rugae pattern). Hard tissue structures are used for bite mark analysis, age and sex determination. Soft tissue structures can be used as a supplement because they have many shortcomings in applying as a definitive tool in forensic odontology [2].

Dental elements can be distinguished in monoradicular, biradicular and triradicular teeth. Incisors and canines of both arches turn out to be monoradicular teeth. All the premolars of lower arch and second premolar of upper arch are monoradicular too. The geometric factors of panoramic projection make the tracing of monoradicular teeth easier than that of biradicular/triradicular teeth.

Any tooth can be utilized to assess age. Among all the teeth, often present in old age are the canines followed by premolars. As canines and premolars are less likely to suffer wear and tear as a result of particular work than other anterior teeth. These teeth have single root with the large pulp area and thus easiest to analyse [3].

It is well known that tissues undergo continuous structural changes throughout life. The two major factors responsible for this continuous process are environmental effects and aging. Tooth morphology, subject to alterations secondary to environmental conditions within the oral cavity, include abrasion, attrition, erosion, caries, periodontal disease and dental treatment. The morphologic changes may take the form of a combination of any of the following phenomenon such as Internal or external resorption, cementum apposition, transparency, pulp stone formation and impaired integrity of the blood vessels [4].

The age-related changes in the dentition could be divided into three categories: formative, degenerative, and histological [5].

The formative or developmental changes are good predictors of age in the early years, until age 12. Formative changes are subdivided into following stages: the beginning of mineralization, the completion of the crown, the eruption of the crown into the oral cavity, and completion of the root. Degenerative changes also provide data for age estimation. The obvious degenerative changes in adult dentition are color, attrition, and periodontal attachment level. Color change is highly variable and is closely related to diet and oral hygiene [5].

Numerous techniques for dental age assessment based on oral and facial structures have been introduced. In general, a distinction is made between invasive and non-invasive methods. For the age determination in living persons, mainly non-invasive techniques are employed. Invasive methods, such as tooth extractions (e.g. required for the determination of aspartic acid racemization from dentin) cannot be used in living subjects for ethical reasons. In contrast, the taking of x-rays is a non-invasive method, which can be employed in both living and dead individuals [6].

Dental age estimation methods

Various methods are utilized for determination of age from dentition. These may be described in four categories namely - clinical, radiographic, histological, physical and chemical analysis.

- **Clinical or visual method**: Visual observation of the stage of eruption of the teeth and evidence of changes due to function such as attrition can give an approximate estimate of age.
- **Radiographic method**: Radiography can provide the gross stage of dental development of the dentition.
- **Histological method**: Histological methods require the preparation of the tissues for detailed microscopic examination, which can determine more accurately the stage of development of the dentition. This technique is more appropriate for post-mortem situations. It is also significant in estimation of age of early development of dentition.
- **Physical and chemical analysis**: The physical and chemical analysis of dental hard tissues to determine alterations in ion levels with age have been proposed.

Age estimation– using Radiographs

The application of radiology in forensic sciences was introduced in 1896, just 1 year after the discovery of the X-ray by Roentgen, to demonstrate the presence of lead bullets inside the head of a victim. Since 1982, dental radiography, a non-destructive and simple technique used daily in dental practice, has been employed in methods of age estimation. Dental findings assessed by radiography are an important source of information in forensic odontological age determination.

Various radiographic images that can be used in age identification are IOPA radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies [7].

The age estimation in adults can be achieved by radiological determination of the reduction in size of the pulp cavity resulting from a secondary dentine deposition, which is proportional to the age of the individual A study was conducted to obtain data on the reliability and reproducibility of two non-destructive dental age estimation methods. Morphological and radiological technique was evaluated on 160 and 72 teeth respectively. They concluded that morphological method of dental age estimation did not differ much from real age. For radiological method, age estimation were statistically comparable with real age, thus non-destructive dental age estimation techniques produce accurate dental age estimation when applied appropriately [8].

A review was done to study the changes of dental pulp complex and their relationship to systemic aging. The normal histological and radiographic counterpart of dentin pulp complex tissue were noted and the radiographic age related changes were discussed and finally concluded that the dental pulp complex could be used as a biomarker of aging [9].

A study was conducted by examining the diameter and length changes of root canal in mandibular anterior teeth in 500 subjects with age ranging from 17 to 29 years which were divided into 6 groups. Measurements of tooth length, coronal length, apical length, root canal length, cervical width, midroot width and apical width were taken and root canal shrinkage was calculated vertically and horizontally. They concluded that there was statistically significant reduction in length and width of root canal with advancing age [10].

Several studies have been conducted using monoradicular teeth for age estimation using radiographs. The teeth used are maxillary and mandibular incisors, canines and premolars.

Kvaal., *et al*. method of Age estimation, in this method pulp-to tooth ratio were calculated for six mandibular and maxillary teeth, such as maxillary central and lateral incisors; maxillary second premolars; mandibular lateral incisor; mandibular canine; and the first premolar. Using intraoral periapical radiographs, pulp-root length (R), pulp-tooth length (P), tooth-root length (T), pulp-root width at cemento-enamel junction (A), pulp-root width at midroot level (C) and pulp-root width at midpoint between levels C and A (B) for all six teeth were measured. Finally, mean value of all ratios excluding T (M), mean value of width ratio B and C (W) and mean value of length ratio P and R (L) were substituted in the given formula given by Kvaal., *et al*.: Age= 129.8 – (316.4 x M) (6.8 x (W-L)**.** The age is derived by using these pulp to- tooth ratios in the formula for age determination [11].

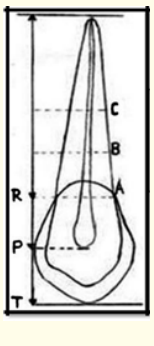

Figure 1: Diagram of premolar showing measurement sites: pulp root length (R), pulp-tooth length (P), tooth-root length (T), pulp root width at cemento-enamel junction (A), pulp-root width at midroot level (C) and pulp-root width at midpoint between level C and A (B) [11].

A study conducted by using 197 digital OPGs of Caucasian individual in the age group 19 to 75 years by selecting six teeth maxillary central incisor, lateral incisors, maxillary second premolar and mandibular lateral incisors, canine and first premolar. Kvaal's technique was applied on digital OPGs and concluded that the age estimation can be done from the panoramic radiographs [11].

Another study was conducted by obtaining 168 OPGs between the ages ranging from 14 to 81 years. Measurements were made digitally from mandibular lateral incisor, mandibular canine, mandibular first premolar, maxillary central and lateral incisor and maxillary second premolar for 6 types of teeth, with the ratios of pulp/tooth length and pulp/root widths at 3 different root levels. Statistical calculations showed linear correlation coefficient of 0.95 with standard deviation of 5.6yrs. They concluded that width ratio of the pulp cavity showed significant correlation to the chronological age and the coefficient of determination was highest in the upper lateral incisor [12].

A study conducted on 100 Italian white Caucasian patients between the age of 18 to 72 years using OPGs of a maxillary right canine. The pulp/root ratio, tooth length, pulp/tooth length ratio, pulp/tooth area and pulp/root width ratios at 3 different levels were measured digitally using Auto CAD 2000 computer aided drafting system. Multiple regression method was used for statistical analysis and 84.9% of variations in estimated chronological age were found and it was concluded that pulp/tooth area ratio correlated with chronological age [13].

Another study was done on variations in pulp/tooth area ratio as an indicator of age. In this study 100 Italian white Caucasian patients (46 men, 54 women) aged between 18 and 72 years. The single rooted maxillary right canine was utilized in this preliminary study. Pulp/root ration, tooth length, pulp/tooth length ratio, pulp/tooth area and pulp/root width ratios at three different levels were computed. Pearson's correlation coefficients between age and these variables showed that the ratio between pulp and tooth area correlated best with age ($r2 = 0.85$). Stepwise multiple regression models yielded a linear relationship between pulp/root width at mid-root level and chronological age and a linear relationship when pulp/tooth area was compared to age. Statistical analysis indicated that these two variables explain 84.9% of variations in estimated chronological age. The median of the absolute value of residual errors between actual and estimated ages was less than four years [14].

A study was performed to estimate adult dental age by pulp/tooth area ratio(PTR) method. They assessed the lateral incisor (LI) and first premolar (PM1) in addition to canine (C) — alone and in combination. Periapical radiographs from 61 Indians aged 21–71 years were examined. PTR of LI produced the best age correlation (r = −0.395) followed closely by PM1 (r = −0.362). The canine revealed the lowest correlation (r = −0.206); among tooth combinations, the three teeth taken together had the best R value (−0.438) followed by LI + PM1 (−0.435), LI + C (−0.406) and C + PM1 (−0.37) [15].

A study conducted by Cameriere., *et al*. to examine the relationship between age and age-related changes in the pulp/tooth area ratio in monoradicular teeth. A total of 606 orthopantomograms of (289 women and 317 men), aged between 18 and 75 years was analysed. Regression analysis of age of monoradicular teeth indicated that the pulp/tooth area ratio of lower premolars regularly decreased with age and ranged from 0.018 to 0.020. and lower premolars were most closely correlated with age [16].

Conclusion

Monoradicular or the single rooted teeth, often present in old age especially the canines followed by premolars. And these teeth are less likely to suffer wear and tear as a result of particular work than other anterior teeth. These teeth have single root with the large pulp area and thus easiest to analyse. Panoramic radiographs are one of the imaging modalities used as a screening images which produce a complete view of both dental arches, their adjacent structures with minimal geometric distortion and minimal overlap of anatomic details from the contra lateral side.

The radiographic method of using pulp/tooth ratio of mandibular canines and premolars is a useful technique to estimate dental age of an adult individual as it helps forensic odontologist to develop a profile of a dead individuals as well as serve in determining age in living subjects.

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