ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Age Estimation with Dental Radiographs.

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ABSTRACT

Radiology plays an indispensable role in human age determination. Radiological images are utilized in the process of age estimation, which is one of the essential tools in identification in forensic science. 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. Developing teeth are used most reliable in age estimation; teeth are the most indestructible part of the body and exhibit the least turnover of natural structure. They therefore not only survive death but also remain relatively unchanged thereafter for many thousands of years. The anticipated developmental sequence that human dentition follows to reach complete dental development can be utilized in age determination. The methods based on the stages of tooth formation as appreciated on radiographs seems to be more appropriate in the assessment of age than those based on skeletal development as the dental development and calcification is controlled more by genes than by environmental factors.

Keywords: Radiographs; age estimation, forensic radiology, dental age, identification.

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ISSN: 0975-8585

INTRODUCTION

Dental identification is one of the commonest means which is applied in identifying deceased individuals who cannot be recognized visually. Post mortem identification requires the investigation of biometric features that are unique to the individual and are capable of withstanding severe perimortem conditions. To this end, dental features still remain as one of the most effective modalities for postmortem identification. Variations in dental characteristics such as tooth angulations, morphology, and/or degree of restoration mostly provide a satisfactory number of distinguishing characteristics comparing with dental records and ante mortem radiographs [1]. Growth rate is dependent on genetic and environmental factors and varies between the sexes, between individuals of the same population and between populations themselves. There is strong concern over the dental and bone testing procedures conducted to determine the age of young individuals for legal reasons. Inaccurate results would lead authorities to imprison some children in adult prisons, which are unsafe and inappropriate for minors [2].

Among the numerous methods of age estimation on the basis of teeth, the progressive change of the coronal pulp cavity has received far less research attention than, for example, has attrition and root dentine transparency. Since 1925 Bodecker identified the apposition of secondary dentine as being related to chronological age. The secondary dentine deposition was included in the method pioneered by Gustafson's (1950), where the dentine transparency and the secondary dentine values showed the highest correlation with age, as the following studies of Johanson (1971), Maples (1978), and Metzger et al. (1980) have demonstrated. Other authors, as Nalbandian and Sognnaes (1960), were also of the opinion that it was necessary to include the secondary dentine for estimating age [3].
The analysis of the digitized images of the available radiographs for the volume measurements has provided new perspectives in the field of age estimation. Innumerable variations of digital radiology techniques can be found in the literature, but essentially the method comprises the following steps: (1) radiographic image digitization with the aid of a scanner or video camera, or image acquisition directly from the X-ray system, coupled with a computer with monitor, printer and CD-ROM recorder; (2) image processing through the appropriate software, with resources for image rotation, translation and scaling, without the necessity of new exposures [4-6].

Chronological age is the actual age of the individual. However, the relationship between growth and chronological age is not" linear and therefore the concept of 'biological' age is used which may be expressed as either skeletal age or dental age. Kullman reported that documentation of birth is one of the most important factors determining chronological age in most developed countries. When the birth date is not known, there will be a strong need to estimate the biological age. The times of appearance and fusion of ossification centres and the size and morphology of different bones such as the neck and wrist are used for estimation of skeletal age. Dental methods for determining biological age are more acceptable than other methods and most of the researchers have used these methods for determining age. These methods have been based mostly on the subjective prediction of radiological stages of dental age [2,7,8].

Methods applied for age determination in children and adolescents:[6]

- Schour and Masseler method
- Moorees, Fanning and Hunt method
- Demirjian, Goldstein and Tanner method
- Nolla's method
- Age estimation using open apices

The triad for odontological age estimation can be listed as: the subject for age estimation; Appropriately chosen dental development survey and legal consideration [9].

Age estimation of adults from dental radiograph [10,11]

With the advancing age the size of the dental pulp cavity is reduced as a result of secondary dentine deposit, so that the measurements of this reduction can be used as an indicator of age. Age estimations from teeth are frequently used because teeth may be preserved long after all other tissues, even bone have disintegrated. Secondary dentine deposits have been regarded as a valuable age factor and measurements of the pulp on radiographs from mandibular incisors have shown a significant difference in direct measurements between 10-year age groups. Secondary dentine has also been measured indirectly on radiograph of extracted teeth. Such measurements were suggested use in non-destructive method to predict age, but so far no reports of age estimation methods based on measurements from radiographs of several teeth from the same dentition. The ratio between pulp and the root have also been used in age estimation, as the size of the pulp is reduced with age.

Age estimation through finger radiograph [12]

It is possible to know the chronological age through assessing the skeletal maturity status. Dental radiographs can be used to take the radiographs of the MP3 (middle phalanx of the third finger) region and by knowing the MP3 developmental status through these radiographs. This method can be used in adolescent and pubertal age group only, it find its application in medico legal and forensic cases since it a simple, non-invasive and reliable method of age estimation. Radiographs of the middle phalanx of the third finger (MP3) are taken to know the skeletal maturation status of the child.

Method of reading MP3 radiographs

MP3 region shows different growth pattern during adolescent period. The different patterns are,

- **MP3 F:** Epiphysis is as wide as metaphysic and it denotes the onset of pubertal growth spurt.
- **MP3 FG:** Epiphysis is as wide as metaphysis and there is a distinct and /or lateral border of the epiphysis forming the line of demarcation at right angle to the lateral border.
- **MP3 G:** The sides of the epiphysis had thickened and also capped its metaphysis forming a sharp edge distally at one or both sides.

- **MP3 H:** Fusion of epiphysis and metaphysis had begun. It is the deceleration period of pubertal growth spurt.
- **MP3 I:** Fusion of epiphysis and metaphysis was complete. It marks the end of pubertal growth spurt.

Advantage

Age estimation during puberty and adolescent is possible with this method.

Disadvantage

The inability to assess the age in all the age groups is a disadvantage of this method.

Age Estimation through Gonial Angle.

Various authors have described number of changes that take place in the morphology of the human mandible with advancing age. One of the prominent changes that have been suggested is the change in the gonial (mandibular) angle. The angle between the ramus and the corpus of the mandible is called the gonial angle. A surface field of resorption is present on the inferior edge of the mandible at the ramus body junction, forming the antegonial notch. Any change in the gonial angle is largely produced by ramus remodeling and is determined by the remodeling direction of the ramus with its condyle. Very few studies have been carried out to correlate the changes in the mandibular angle with age, sex and dental status [13-16]. Previous reports on widening of the gonial angle in edentulous patients are conflicting. Aside from age and loss of teeth, other factors may influence change in gonial angle. Panoramic radiograph is the most obvious choice for determination of the gonial angle [15], antegonial angle, and antegonial depth and their relationship to gender, age group, and dental status. Previous literature suggests that, as age advances, the gonial angle decreases and becomes less obtuse in adulthood and again increases as the age advances towards old age. Cross-sectional studies have promoted the view that the gonial angle is increased by age and by the edentulous state. Longitudinal studies do not support this view [14]. In males, the gonial angle decreased up to 55 years and became obtuse as the age advances. In females, the gonial angle decreased up to 55 years, increased in 56–65 years, and again decreased above 65 years of age. The literature shows discrepant results concerning the changes in the gonial angle with age and dental status. Casey and Emrich [17] found no statistical significant difference in gonial angle in the edentulous and dentulous sides.

The Accuracy of Dental Panoramic Radiography as an Indicator of Chronological Age

Dental age may be expressed in terms of the time of emergence of teeth or the state of maturation of their mineralization. Some studies have suggested that growth and development of the third molar can be determined easily. Usually, the third mandibular molar tooth can be visualized radiologically at 9 years of age. Kullman *et al.* showed that only wisdom teeth are useful for determining age as their maximum developmental age is only after 14 years of age. Experience has shown that panoramic radiography is very important for certain diagnoses. It is also useful for determining the completion of the

stages of wisdom teeth, viewing all the four regions of the jaw in a single radiograph and to know the position of the third molar teeth. The use of radiographs is based on the degree of formation of root and crown structures, the stage of eruption, and the intermixture of primary and adult dentitions [2,18].

Biological age estimated by three methods:

- Use of panoramic radiographs for all wisdom teeth seen in radiographs (Demirjian's method) [19]
- The state of the apex of the extracted wisdom teeth roots (based on the criteria of Peterson).20
- Radiography of the hand (Greulich and Pyle classification) [21].

In a study of 197 panoramic radiographs of the teeth from 94 boys and 103 girls, randomly selected from various schools in Belgium from the age group of 613 years known chronologic age, significant positive correlation was found between chronological and dental age [2] The hand-wrist radiograph is commonly used for skeletal developmental assessment. Most investigators have found significant correlation among maturation stages derived from hand-wrist radiographs, changes in height during pubertal growth period, and facial growth [2,7,18] Panoramic radiographs were used to assess dental maturity because they are routinely available in orthodontic clinics, and the mandibular region is clearly visible. There are a number of standard scales for rating the tooth calcification stage. The method described by Demirjian *et al.* consists of distinct details based on shape criteria and proportion of root length, using the relative value to crown height rather than on absolute length [2].

Correlation of chronological and radiological age in human by Demirijian method [6].

Demirjian, Goldstein and Tanner method: Demirjian, Goldstein and Tanner30 rated seven mandibular permanent teeth in the order of second molar (M2), first molar (M1), second premolar (PM2), first premolar (PM1), canine (C), lateral incisors (I2) and central incisor (I1) and determined eight stages (A to H) of tooth mineralization together with stage zero for nonappearance If there is no sign of calcification, the rating 0 is given; the crypt formation is not taken into consideration.

Stage description

In both uniradicular and multiradicular teeth, a beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcification points;

- Fusion of calcified points forms one or more cusps which unite to give a regularly outlined occlusal surface, or mineralized cusps are united so the mature coronal morphology is well defined;
- Crown half-formed, pulp chamber is evident, dentinal deposition is occurring;
- The crown formation is completed down to the cemento-enamel junction, pulp chamber has a trapezoidal form and beginning of root formation is seen;

- Initial formation of the radicular bifurcation is seen, the root length is still less than the crown height;
- The apex ends in a funnel shape; the root length is equal to or greater than the crown height;
- The walls of the root canal are now parallel and its apical end is still partially open;
- The apical end of the root canal is completely closed; the periodontal membrane has a uniform width around the root and the apex.

This method is the most highly developed of all dental age surveys; the only drawbacks are that the survey does not include the developing third molar and the mandibular teeth need to be present for the survey to be applicable.

CONCLUSION

Saunders, a dentist, was the first to publish information regarding dental implications in age assessment by presenting a pamphlet entitled ''Teeth A Test of Age'' to the English parliament in 1837. While quoting the results from his study on 1000 children, he pointed out the value of dentition in age estimation. The age assessment methods are relatively simple and involve the identification of the stage of mineralization on radiographic images followed by their comparison with the standard stage to estimate the approximate age range. Various radiographic images that can be used in age identification are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies. The radiographic images must be such that they include developing teeth of interest and that all the stages of dental development can be rated according to chosen development standards. In forensic radiology, there is a need to assess the chronological age, which is the actual age of the patient. The stages of tooth formation can be used to estimate the chronological age in young persons by applying the appropriate dental survey. Very few attempts have been made to find common standardization, calibration and evaluation procedures for methods of age estimation or to develop means of quality assurance for them. Efforts in this direction are necessary to assure the quality standards and adequate answers to the important legal and social issue of age estimation in forensic science.

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