THE ACCURACY OF DENTAL PANORAMIC RADIOGRAPHY AS AN INDICATOR OF CHRONOLOGICAL AGE IN IRANIAN INDIVIDUALS

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ABSTRACT

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.

This study was designed to determine the relationship between dental age, the age from dental panoramic radiography, skeletal age and chronological age in patients referring to dental clinics of Yazd, Iran, for third molar surgery. The sample for the study consisted of 58 subjects between 15-25 years of age. The results indicated that estimating the age by examination of extracted lower wisdom teeth was most accurate. However, as use of this method i.e. extraction of tooth or dental surgery is not possible in normal individuals. Estimating the age from dental panoramic radiography showed high accuracy when applied to the patients.

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Key words: Dental age, chronological age, panoramic radiography

INTRODUCTION

Growth rate is dependent on genetic and environmental factors and varies between the sexes, between individuals of the same population and between populations themselves. The underlying basis of this variation is genetically determined but the expression of the growth process is under the influence of environmental factors.[1,2] These differences demonstrate in the timing of calcification and mineralization of teeth.[3,4] Postnatally, skeletal maturation is more developed in girls than boys but bone mineral density is less in girls than boys, the latter having larger and longer bones.[5-9]

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[10] 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.[11] 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.[10]

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.[12] Kullman et al.[13] showed that only wisdom teeth are useful for determining age as their maximum developmental age is only after 14 years of age. In Hispanics, the completion of the third maxillary molar is after the completion of third mandiblar molar.[14]

Eruption of the teeth and their stage of mineralization have been used in dental ageing. It is accepted that the process of mineralization is genetically determined,[15,16] whereas eruption appears to be affected by systemic influences such as nutrition or local conditions.[17,18] Mesotten et al.[19] performed a study and showed the relation between the root of the third molar and chronological age. Similarly, the Arany et al.[20] study indicated that the direction of radiographic completion of the third molar is related to chronological age in a young Japanese population.

In dentistry, awareness about the growth potential of a patient is one of the most important factors determining the success of orthodontic treatment. In addition, occasionally the legal system requires an assignment of age so that appropriate procedures may be observed, for example, where there is a legal age for criminal responsibility. In certain countries, criminals lacking birth certificates may be obliged to prove under-age status in order to avoid the death penalty.

Human dentition follows a reliable and predictable developmental sequence, beginning about four months after conception and continuing to the beginning of the third decade of life when development of all the permanent teeth is completed.[21]

Owing to a comparatively low variability of tooth formation in relation to chronological age,[22] it seems that methods based on stages of tooth formation are more appropriate in assessment of chronological age than those based on other indicators of somatic development.[23]

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.[24] 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.[25]

Thorson and Powell[26] indicated the value of completion of third mandibular molars in panoramic radiographs for determining age for young foreigners in Scotland whose exact birthdates were not known. Willershausen et al.[27] showed that developmental stages of the third molar are a lone indicator of age in the young but not so in matured individuals where other guidelines and factors about age are needed.

The aim of this study was to explore the connection between chronological age and biological age estimated by using radiography of the wrist, panoramic radiographs and examination of extracted wisdom teeth.

MATERIALS AND METHODS
This study was conducted as a cross-sectional and diagnostic study with the cooperation of the Forensic Medicine Department and Dental Medical College of Yazd in the year 2004-2005, at the Faculty of Dentistry, Shahid Sadoughi Medical University, Yazd, Iran. The ethical committee of the university approved this research.

The sample consisted of 58 patients, randomly selected from patients of the age group of 15-25 years known chronological age, referring to dental clinics in Yazd for extraction of third molars. Chronologic age of an individual was calculated by subtracting the birth date (based on their official birth certificate) from the date on which the radiographs were exposed for that particular individual. Decimal age was taken for simplicity of statistical calculation and ages were estimated on a yearly basis e.g. 9 years 9 months as 9.75 years. From the total of 58 patients, 36 were women and 22 were men. The average age was 19.85+/-2.6 years with a range of 14.4-25 years. The distribution of the samples in different age groups was similar as follows: four individuals were in 15-16 years old group, five were in 16-17 years, six in 17-18 years, nine in 18-19 years, five in 19-20 years, seven in 20-21 years, seven in 21-22 years, seven in 22-23 years, seven in 23-24 years and eight were in the 23-25 years old group.

The criteria for selection of cases for the present study were as follows:
a. Subjects were clinically free from any developmental, endocrine or nutritional disorder.
b. Subjects were clinically free from any past prolonged illness.
c. Subject should be clinically free from any special dental diseases such as dysplasia of enamel or dentine.
d. Those who had broken teeth during surgery were excluded from the study.

The patients' biological age was estimated by three methods:
1. use of panoramic radiographs for all wisdom teeth seen in radiographs (Demirjian's method[28,29])
2. the state of the apex of the extracted wisdom teeth roots (based on the criteria of Peterson[30])
3. radiography of the hand (Greulich and Pyle classification[31]).

All the panoramic radiographs were taken in one clinic by one technician under similar conditions. The radiographs were taken on T Mats with dimensions 15x30 cm by a Planmeca 2002 EC Proline machine* with a maximum of 80 mili amps and timing of 18 seconds. The films were developed by automatic machines; Velopex Extra-X** with a timing of four minutes at 27°C . On visualization of the wisdom teeth, the radiographs were given a code and then the shape of the radiograph and the teeth was drawn with a soft B2 pencil on a size A4 tracing paper. Then, these papers were given to two oral and maxillofacial radiologists for confirmation of age. These confirmations of ages were repeated again at an interval of three weeks. In case of difference between the two estimates, the average age was calculated. To test the agreement between these radiologists the required test was performed and the agreement and reliability was confirmed.

The extracted wisdom teeth were placed in 10% formalin and were examined by one dental surgeon to estimate the age on the basis of root formation.

A hand-wrist radiograph was taken after informed consent was obtained from patients. These radiographs were taken at the same radiology clinic under similar conditions. A Varian Medical system§ with 100 mili amps, 46 kilo volts and 40 miliseconds with Kodak§§ film in two sizes; 18x24 and 24x30 cm was used in the study. Two radiologists examined the radiography of the wrist and estimated the biological age based on their observations.

In all three methods, the age estimation was repeated by the same person (without the knowledge of previous age estimate) at an interval of one week for 15 randomly chosen samples to test the reliability of these methods.

Statistical analysis was carried out by paired t-test using SPSS software version 11¶.

Table 1: The results of the estimated ages by different methods

Method	Details	Number	Mean of age (years)	Standard deviation
Chronological age	Birth certificate	58	19.846	2.599
Panoramic radiography	Upper left	33	19.106	1.819
	Upper right	33	18.864	2.220
	Lower left	53	19.123	2.002
	Lower right	46	19.330	2.050
Extracted wisdom teeth	Upper left	30	19.567	2.123
	Upper right	25	18.940	2.123
	Lower left	49	19.745	2.232
	Lower right	40	19.550	2.342
Wrist radiography	1st radiologist	58	18.716	1.478
	2nd radiologist	58	17.708	0.683

Table 2: Statistical analysis of the differences between the chronological age and estimated age by different methods

Method	Details	Coefficient correlation	p-value
Panoramic radiography	Upper left	0.554	0.001
	Upper right	0.589	0.000
	Lower left	0.613	0.000
	Lower right	0.697	0.007
Extracted wisdom teeth	Upper left	0.715	0.000
	Upper right	0.756	0.000
	Lower left	0.823	0.000
	Lower right	0.798	0.000
Wrist radiography	1st radiologist	0.763	0.000
	2nd radiologist	0.235	0.107

RESULTS

The results of the estimated ages are shown in Table 1. These results were compared with the actual chronological age in order to determine the best method for estimating age. All of the estimated ages were lower then the chronological age of patients (Table 2). Estimating the age by examination of lower jaw wisdom teeth was most accurate, but as use of this method (extraction of teeth or dental surgery) is not possible in most cases, other methods were studied more accurately. In panoramic radiographs, the least age difference between the estimated age and real age was seen in the right lower wisdom teeth (5.5 months) and right upper wisdom teeth (6.6 months). Overall, in panoramic

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*   Planmeca, Helsinki, Finland
**   Medivance Instruments Ltd, London, England
§   Varian Canada Inc., Montreal, Canada
§§   Kodak Industrie Laboratories, Chalon-sur-Saone, France
¶   SPSS Inc., Chicago, USA

radiographs, we can estimate the age from any of the four wisdom teeth or from all of them as a group.

The average difference between the age estimated by examination of wisdom teeth and chronological age was calculated (Table 3).

The maximum recorded errors were in connection with radiography of the wrist and both the radiologists estimated the age less than

Table 3: *The average difference between the chronological age and estimated age by different methods*

Method	Details	Mean difference (months)	Standard deviation	Confidence interval 95%	p-value
Panoramic radiography	Upper left	7.8	25.4	16.8	0.087
	Upper right	6.6	25.8	15.8	0.151
	Lower left	9.7	24.7	16.5	0.006
	Lower right	5.5	22.6	12.2	0.104
Extracted wisdom teeth	Upper left	5.1	21.2	13	0.198
	Upper right	5.1	19.2	11	0.423
	Lower left	2.6	17.4	7.6	0.296
	Lower right	1.6	19.2	7.8	0.602
Wrist radiography	1st radiologist	13.6	21	19.1	0.000
	2nd radiologist	27.1	29.3	35.6	0.000

the chronological age (p value=0.000). The minimum errors recorded were for the estimated age of the wisdom teeth extracted from the right lower side (mean 1.6 months).

By use of the appropriate statistical analysis for estimating the percentage of prediction errors for each method, it was shown that the number of individuals with a chronological age not included in the 95% CI provided by age estimation were less than 5% in all three methods. Our results indicated that there is no significant difference in the age estimate by using age on the basis of visualization of any of the wisdom teeth. To find the best method for estimation of the age in panoramic radiography, different combination of images from wisdom teeth were investigated. For example, two of these combinations are as follows; by combination of the right-sided wisdom teeth in panoramic radiographs, the mean difference of the estimated error from the chronological age was 2.54+/-23.1 months with confidence interval of 95% ranging between -4.17 and +9.24 months (p value = 0.45). Furthermore, by using age on the basis of the combination of four wisdom teeth, the mean difference of the estimated error from the chronological age was 1.67+/-23.60 months with confidence interval of 95% ranging between -4.54 and +7.87 months (p value=0.592).

In panoramic radiographs, the maximum percentage of similarity between the chronological age and estimated age was an estimate from the upper right wisdom tooth (39.4%), followed by the age calculated from the average of estimate from the right upper and lower teeth (33.3%). In cases where there is no upper right wisdom tooth, the lower wisdom teeth could be used with less accuracy (left lower 24.5% and right lower 23.9%).

Therefore, the age estimated from the right upper wisdom teeth is the best method used. All the said methods were estimated according to the sex and there was not any statistical difference between men and women (p value>0.05).

DISCUSSION

Estimating age from the teeth has several advantages over skeletal ageing. The development of both the deciduous and permanent teeth can be studied from the embryonic period until early adult life. In addition, it is commonly observed that, for a given chronological age, dental age shows less variability than does skeletal age.[28,32] Dental development is less affected than bone by adverse environmental circumstances such as nutrition and disturbances of endocrine function.[16,28] The reasons of less variability in dental age are not fully understood. A possible reason is that the development of all the deciduous dentition and part of the permanent dentition takes place before birth in a protected environment whereas skeletal growth and development, even though having a strong genetic basis, is exposed for an increasing length of time to external factors such as variations in nutrition, socio-economic status and possibly climate.

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 6-13 years known chronologic age, significant positive correlation was found between chronological and dental age.[33]

There is strong concern over the dental and bone testing procedures conducted by dentists and physicians who are attempting to determine the age of young individuals for legal reasons. Inaccurate results would lead authorities to imprison some

children with adult prisoners, which is unsafe and inappropriate for minors.

It is important to know the stage of maturation of a patient, which can have a considerable influence on diagnosis, treatment goals, treatment planning, and the eventual outcome of orthodontic treatment. The technique for assessing skeletal maturity consists of visual inspection of the developing bones. Various areas of the skeleton have been used: the foot, the ankle, the hip, the elbow, the hand-wrist, and the cervical vertebrae.[19]

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.[10,13,20]

The last physiologic measure is dental maturity, which can be determined by the stage of tooth eruption or the stage of tooth formation. The latter is proposed as a more reliable criterion for determining dental maturation.[11,34,35] Relationships between the calcification stages of individual teeth and skeletal maturity have been previously reported. Racial variations in the relationships have also been suggested. Unfortunately, little is known of this relationship in Iranian children and adolescents. The objective of this study was to investigate the relationships between the stages of calcification of various wisdom teeth and skeletal maturity stages among Iranian individuals. The findings from this study will establish a valid clinical tool for indicators of the pubertal growth period in Iranian children, adolescents, and young adults without the necessity of resorting to hand-wrist radiographs.

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.[34] The method described by Demirjian et al.[29] was chosen in the present study because its criteria consist of distinct details based on shape criteria and proportion of root length, using the relative value to crown height rather than on absolute length.

The findings of this study indicate that tooth calcification stages might be clinically used as a maturity indicator of the pubertal growth period. However, because of the small size of samples in this study, we must be conservative in the interpretation of these results and therefore further studies are recommended in a larger sample size, and they should address development of the canines and second molars as well.

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