Age estimation of Malawian adults from dental radiographs

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Summary

Background: **Previous studies have shown that with advancing age the size of the dental pulp cavity is reduced as a result of secondary dentine deposit, so that measurements of this reduction can be used as an indicator of age. Age estimation is one of the indicators used in forensic identification and teeth are biological markers for human age estimation.**

Methodology: **We measured the height (mm) of the crown (CH = Coronal Height) and the height (mm) of the coronal pulp cavity (CPCH = Coronal pulp cavity height) of premolars and molars of 134 adult Malawians (77 males, 57 females) aged 20 – 80 years from dental radiographs. The Tooth-Coronal Index (TCI) was computed for each tooth and regressed on real age.**

Result: **The correlation coefficients ranged from r – 0.650 to – 0.799 and were significant in both gender, in premolars and molars ($P < 0.01$). The equations obtained allowed estimation of age with an error of ±5 years in our studied population, the molar equation estimated age better for males while the premolar equation was for female and combined samples. The percentage accuracy levels of our sample population were higher than Caucasians previously reported using similar methods.**

Conclusion: **Our study demonstrates the potential value of this method of age estimation which is precise, simple, non invasive and applicable to both living individuals and skeletal materials of unknown age.**

Key -words: ***Teeth, Age estimation, Dental radiographs, Malawians.***

Résumé

Introduction: Des études précédentes avaient montré qu'avec des développements la dimension de la cavité du pulpe dentaire est en baisse à la suite du précipite dentine secondaire, pour pouvoir utiliser les mesurage de cette réduction comme un indicateur d'âge. Estimation d'âge est l'un des indicateurs utilisés dans l'identication légale et les dents sont des marqueurs biologique pour décider l'âge de l'homme.

Méthodology: Nous avons mesuré la heuteur (mm) de la couro nne (HC = Hauteur coronaire) et la heuteur (mm) de la cavité du pulpe coronaire (HCPC = heuteur de la cavité du pulpe coronaire) du. Prémolaire et molaire des 134 adultes malawians (77 du sexe masculin, 57 du sexe féminin âgé de 20 - 80 ans de la radiographie dentaire. L'index du dent coronaire (IDC) était calculé pour chaque dent et regressé sur le vrai âge.

Résultat: Le coefficient de la corrélation aller de r - 0,650 à - 0,799 et etaient important chez les deux genres, dans les prémolaires et molaires ($P < 0.01$). L'équation obtenue a tenu compte d'estimation d'âge avec une erreur de ± 5 ans dans notre population étudiée, l'équation molaire avait évalué l'âge mieux pour le sexe masculin tandis que équation molaire était pour le sexe féminin et echantillons combinés le taux du pourcentage d'exactitude de notre échantillon de la population était élevé plus que caucasians rapportés précédemment à travers l'utilisation de la même méthode.

Conclusion: Notre étude a indiqué la valeur potentielle de cette méthode d'évaluation d'âge qui est exact, simple, non invasif et applicable au deux individus vivants et matériel squelettique d'âge inconnu. Nous recommendons cette méthode pour les pays en voie de développement.

Introduction

Age estimation is one of several indicators employed to establish identity in forensic cases and teeth are very often used as biological markers for human age determination. Age estimation from teeth is frequently used, because they may be preserved long after all other tissues including bones have disintegrated. Similarly, unlike bones they can also be inspected directly in living individuals. Such estimations of living individuals are made for refugees or other persons who arrive in a country without acceptable identification papers and may require a verification of age, in order to be entitled to civil rights and/or social benefits in present-day society. Furthermore, in archeological research, estimation of age at death for skeletal remains was a technique employed in describing palaeodemology of populations[1]. It may also be used in studies of archeological material for identification of an unknown dead body.

Several methods of age estimation using teeth are available [2-6] with the most widely applied being rather time-consuming and in many cases, requiring sophisticated laboratory equipment for preparing longitudinal sections. Other methods based on the dynamics of the tooth eruption process are limited to the short period of odontogenesis [7-11].

The least known but easily applied method of age estimation is based on secondary dentin deposition clearly seen on dental radiographs since with advancing age the size of the dental pulp cavity is reduced as a sequence of secondary dentin concrements [6, 12]. Despite the fact that this method has received little attention in research, the height of the coronal pulp cavity has been shown to have a significant correlation with chronological age [4, 12-14]. This correlation was shown to be especially high for female and male molars, ranging from – 0.87 to – 0.92 respectively [14].

Some dental age estimation methods, which are frequently used, require tooth extraction while others require preparation of microscopic sections of at least one tooth [15-17]. Because these methods are time-consuming, expensive sometimes and

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destructive, they may be unacceptable for ethical, religious, cultural or scientific reasons. Furthermore, a study has shown that age estimation based on the Tooth Coronal Index (TCI) method is at least as precise as most of these widely applied and acknowledged procedures [18]. This method is based on the relationship between age and the pulp size on periapical dental radiographs. It is used often in many dental surgeries, is non-destructive and information is easy to obtain.

This study was therefore carried out on adult Malawian subjects using the tooth coronal index (TCI) method because of its simplicity, non-invasiveness and reliability in age estimation.

Materials and methods

Full mouth dental radiographs (Orthopantomographic) were collected from the records of Queen Elizabeth Central, Blantyre Adventist Hospitals, Wendo and Shalom Dental Clinics all situated in Blantyre City. The radiographs were from134 individuals (77 males, 57 females), with ages ranging from 20 – 80 years and a mean age of 33 years.

A preliminary study on radiographs from 20 individuals showed that measurements from mandibular second premolars and molars were most strongly correlated with age, so these teeth were selected for the investigation. Furthermore, a paired t-test on these measurements showed that there were no significant differences between teeth from the left and the right side of the jaw. Consequently, in this study teeth from either the left or the right side were chosen, whichever were best suited for measurement. Teeth, which were impacted, had vestibular radio-opaque fillings, crowns, pathological processes in the apical bone visible on the radiographs or had already been root-filled were discarded.

Using a digital caliper to the nearest 0.01mm, two observers independently took the following measurements (in millimeters) on the radiographs with fully visible pulp cavity: Height of the crown (CH) and height of the coronal pulp cavity (CPCH) (Fig 1). A straight line traced between the cemento-enamel junction is the division between the anatomical crown and root. The crown height was measured vertically from the cervical line to the tip of the highest cusp according to Moss et al., [19]. The coronal pulp cavity height was measured vertically from the cervical line to the tip of the highest pulp horn after Ikedia et al., [13]. Since dental wear influences the crown length, teeth with marked degrees of attrition (i.e. from stage 5 to stage 8) after Smith [20] were excluded from the study. The focus-film distance of the radiographs was 90cm (36 inches). All the measurements were carried out twice by the two individuals and the mean recorded to minimize intra and inter observer errors.

Using the mean of the measurements of two observers, the tooth-coronal index (TCI) for each tooth was then calculated as follows: $TCI = CPCH \times \frac{100}{CH}$

The teeth were divided into premolar and molar for statistical analysis. Simple linear regression using the Microsoft Excel Package for Windows 2000 was carried out by regressing the Tooth-Coronal Index (TCI) against actual age for each group of teeth for males and females and for the combined sample.

This use of an index instead of absolute measurement excludes possible errors resulting from different scales of X-ray photos [14, 21, 22]. To test for reproducibility of the measurements, they were repeated on the radiographs from ten individuals by both observers, then age predicting equations for Malawians were calculated using linear regression analysis. The success of these equations was analysed based on the percentage accuracy achieved from the estimated ages.

Results

Table 1 shows the age and gender distribution of the studied population. The mean age and standard deviation (SD) in years for males was 33.77 ± 13.10 while for females it was 31.93 ± 14.10. Similarly, the mean age and SD for both gender was 33.00 ± 13.85.

Table 2 shows the Tooth-Coronal Index (TCI) and gender distribution of the studied population with respect to the premolars and molars. Generally the mean TCI for molars were lower than those of premolars in both gender separately and when combined.

Table 3 shows the correlation coefficients between age and TCI by gender and tooth type. The correlations were significant in both gender and in premolars and molars ($r = -0.650$ to -0.799; $P < 0.01$).

Table 1 Age and gender distribution of the Malawian population

Gender	Age range Years	Mean age ± standard deviation SD (years)
Male (M)	20 - 79	33.7 ± 13.10
Female (F)	20 - 80	31.93 ± 14.10
Male + Female (M + F)	20 - 80	33.00 ± 13.85

Table 2 Tooth-Coronal Index (TCI) and gender distribution of the Malawian population

Gender	TCI Range	Mean TCI ± SD
	Premolars	
Male (M)	05.63 - 47.83	28.18 ± 09.19
Female (F)	09.57 - 45.07	28.85 ± 07.93
Male + Female (M + F)	05.63 - 47.83	28.85 ± 08.67
	Molars	
Male (M)	06.11 - 37.75	24.39 ± 05.52
Female (F)	07.91 - 41.73	26.06 ± 07.85
Male and Females (M+F)	06.11 - 41.73	25.10 ± 07.79

The regression equations for premolars were as follows:

$Y = 66.04 - 1.145X$ male
$Y = 67.71 - 1.230X$ female
$Y = 66.89 - 1.175X$ combined sample

While for molars it was:

$Y = 68.38 - 1.419X$ male
$Y = 61.56 - 1.168X$ female
$Y = 65.82 - 1.308X$ combined sample

X represents values of TCI for premolars and molars

Table 3 Correlation coefficients between age and TCI (r) by gender and tooth type

Gender	r	t-value	df	P-value	Significance
		Premolar			
Male (M)	-0.767	-10.336	75	<0.01	s
Female (F)	-0.691	-7.091	55	<0.01	s
Male and female (M + F)	-0.735	-12.465	132	<0.01	s
		Molars			
Male (M)	-0.799	-11.515	75	<0.01	s
Female (M)	-0.650	-6.341	55	<0.01	s
Male and female (M + F)	-0.735	-12.469	132	<0.01	s

Table 4 Equation predicting age (Y) from the TCI method by gender and tooth type

Gender	n	SE	r	Prediction equation
		Premolars		
Male (M)	77	-09.15	-0.767	Y = 66.04 - 1.145X
Female (F)	57	-10.62	-0.691	Y = 67.71 - 1.230X
Male and female (M + F)	134	09.62	-0.735	Y = 66.89 - 1.175X
		Molars		
Male (M)	77	-08.62	-0.799	Y = 68.38 - 1.419X
Female (M)	57	-11.23	-0.650	Y = 61.56 - 1.168X
Male and female (M + F)	134	-09.64	-0.735	Y = 65.82 - 1.308X

X = TCI value

Table 5 Percentage in accuracy levels in age prediction testing equations from the TCI method

Gender	n	% in accuracy levels ± 5 years
	Premolars	
Male (M)	77	49.35
Female (F)	57	40.35
Male and female (M + F)	134	47.76
	Molars	
Male (M)	77	53.25
Female (F)	57	28.07
Male and female (M + F)	134	37.31

Table 6 Comparison of percentage in accuracy levels ± 5 years between Caucasian+ and Malawian populations

Gender	Caucasians+	Malawians
	Premolars	
Male (M)	41.67	49.35
Female (F)	35.48	40.35
Male and female (M + F)	40.91	47.76
	Molars	
Male (M)	34.06	53.25
Female (F)	22.54	28.07
Male and female (M + F)	30.43	37.31

+ Zadzinska et al, 2000

respectively (Table 4).

Table 5 shows the percentage in accuracy levels in age prediction testing equations from the TCI method. The best estimation was obtained for males using the premolar equation of the sample with an error of ± 5 years in 53.25% of the cases while the best estimation for female and combined samples was the molar equation, with 40.35% and 47.76% accuracy levels respectively.

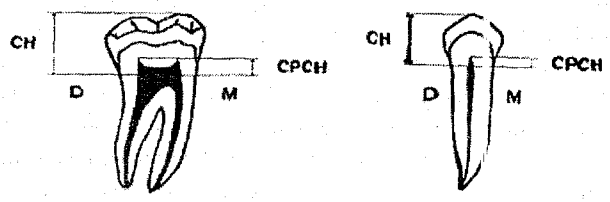

Fig. 1 *Schematic representation of measurements taken off a radiograph. The line traced between the distal (D) and mesial (M) enamel of the premolar and molar represents the division between the anatomical crown and root.*

CH, Corona Height; CPCH, Coronal Pulp Cavity Height.

Table 6 shows the comparison of percentage in accuracy levels between Caucasians as reported by Zadzinska et al., [18] and the present study. The Malawian population showed higher percentage levels of accuracy in both gender using premolar and molar equations.

Discussion

Our study has demonstrated a higher degree of correlation between age and TCI in Malawian males than females, with the correlation also higher for the premolar than molar teeth in general. This may be an expression of the

overall size of the pulp cavity. The high correlations show that the extent of the coronal pulp cavity is easily visible in premolars and molars in dental radiographs as was indeed shown by Drusini et al., [14] using panoramic radiography.

Gender appears to have a significant influence on age estimation using the Tooth-coronal index (TCI) method as opposed to the study of Drusini et al., [14] and hence there is the need for sex-specific formulae in our sampled population. Testing of these equations revealed that the molar equation had higher percentage accuracy in males, while the premolar equation was more accurate for females and the combined samples. We believe that the molar equation is more appropriate for age estimation of Malawian males, and the premolar equation for females and those of unknown gender. Furthermore, the age of more Malawians was estimated than Caucasians previously studied [18] using similar methods indication of a probable racial variation.

The basis of this method of study is the successive deposition of layers of secondary dentin in the pulp cavity during human life such that more years of life meant more secondary dentin deposition, resulting in a smaller height of the coronal pulp cavity. There is therefore a reversal of the interdependence between calendar age and root dentin transparency with more years of life leading to a higher level of translucent dentin in the root [18].

However, the examination of dental radiographs of fully developed teeth was rarely advocated for use in age estimation despite its many advantages. Furthermore, the method can be employed both on living individuals and on the unknown dead, either in identification cases or in archaeological investigations [12]. The use of an index instead of absolute measures obviates the need to standardize tooth size on the radiographs. So, whatever films are available, can be used for age estimation [14].

In age estimation studies, dental attrition is a factor, which must be acknowledged. However, attrition is related to diet, habits and culture [23, 24] and therefore the results of our study will only be applicable to the Malawian population and those, which do not deviate much from it. There is therefore, the need for similar studies in other parts of the world, especially in Africa. This study therefore illustrates the potential value of a little-known but precise aging method, which can be easily applied to estimate age in both living individuals and skeletal materials of unknown age.

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