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Comparison of Two Radiographic Dental Age Estimation Methods – A Pilot Study

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Abstract

Background: Forensic Dentistry, which is also referred to as Forensic Odontology is defined by James cotton as the branch of dentistry, which deals with proper handling, and examination of dental evidence and the proper evaluation and presentation of dental findings in the interest of justice. Teeth are most durable structures in the human body and have been found in many archeologicalsites or forensic cases, as only human remnants. Due to the low variability of dental maturity indicators, they have used for the estimation of chronological age in individuals. Age estimation using teeth play an important role in identification of humans in mass disasters and accidents. In addition, chronological age is important in most societies for school attendance, social benefits, employments and marriages.

Morphological and radiological techniques are used for the estimation of age in adults. There are few radiological techniques which have been devised on American, European or French, Canadian population. These techniques need to be validated for Indian population by doing several studies in different parts of India. In the present study, an effort is made to compare

two age estimation methods namely Cameriere Method and Kvaal's method of individuals by non-destructive radiographic method.

Conclusion: Cameriere's method was found to be more accurate for the current population than Kvaal's method of radiographic determination.

Keywords: Forensic dentistry; Dental evidence; Mass disaster; Radiographic age determination

Introduction

Since the earliest times, the primary tools in the investigation of forensic cases have been observation and interpretation of physical evidence. In the second half of the nineteenth century, advancement in applied forensic science was used to investigate cases which improved the validity of the conclusions drawn[1].

Age estimation is an important division of forensic odontology especially when the subject under question is unidentified. The estimation should be as close to actual age as possible to narrow down the list of missing persons to enable time and energy saving. Age estimation is also used in cases of accidents and mass disasters along with sporadic crime investigations. In addition chronological age is important in most societies for school attendance, social benefits, employment and marriage[2].

Dental maturity indicators help in estimating age of individuals with more accuracy because of their low variability. In children the developmental stages of teeth help in estimating age and in adults' morphological and radiological techniques are used[2].

Morphological techniques are invasive and require extraction and / or histologic sectioning of teeth, which can't be done because of ethical concerns[3]. Radiographic age estimation is a non-destructive, simple method and descriptions in charts yield "maturity scores", which help us to assess the age of an individual[4].

Forensic odontologists can utilize these techniques that are relatively precise and accurate, and avoid the bias inherent in observer subjectivity[4]. Ethnic differences between various population groups were found to affect the accuracy resulting in overestimation or underestimation of the dental age. Since the various studies for assessing the dental age have been conducted predominantly on the Western population, and India being a large country studies from different parts of India are needed. To compare two radiological methods of age estimation namely Cameriere's and Kvaal's method, as a pilot study.

Material & Methods

The pilot study was done as a retrospective study from the archival radiographs and case sheets with 30 samples (Table 1) with an age range of 39-46 years having 20 females and 10 males. The chronological age of the patient was calculated from the date of birth of the patient.

Inclusion criteria

1. The subject should be clinically free from any developmental, endocrinal and nutritional disorder as these may affect development of individuals.
2. Subject should not have past history of clinically free from any past prolonged medical / dental illness.
3. The selected tooth on the radiograph i.e. the mandibular canine is fully erupted into the oral cavity.
4. The root of the canine is fully formed.

Exclusion criteria

1. Teeth with any pathology, such as, caries or periodontitis or periapical lesions, which would alter the surface area of the tooth.
2. Malaligned canines or rotated canines.
3. Canines with any prosthetic fittings.

The digital form of intraoral periapical radiographs of mandibular canine was retrieved from the archives in JPEG format.

The sample

Total 30 samples have been collected and analyzed. Random sampling method was used to collect samples from males and females from routine O.P.D. The chronological age of the patient was noted from patient's history taking.

Procedure

- After clinical examination radiographic examination is done in the form of Intraoral Periapical Radiograph (IOPA) with RVG.
- The radiographic image is directly stored in a digital format.

Sample Analysis

Samples are analyzed by Carmeriere's method and Kvaal's method for the determination of dental age with mandibular canine of the individual. The radiographic images were imported to image morphometry software. For Cameriere method the tooth outline is traced and the tooth area is measured using the area measurement tool of image morphometry software. (Figure 1). Similarly, the pulp outline is traced and the pulp area is measured. Using tooth area and pulp area, pulp/tooth ratio (x) is calculated. For Kvaal's method the pulp width and tooth width was recorded at different levels as shown in Figure 2.

Dental age assessment by Cameriere method

All morphological variables and the chronological age of the patient were again entered in "Microsoft Excel" spread sheet for use of age estimation and age was calculated using the linear regression equation developed by Cameriere et al (2007) for mandibular canines.

Age = 89.456 – 461.873(x)

Dental age assessment by Kvaal's method

Following distances were measure on the canine on radiograph by using imaje morphometric software -

1. Maximum tooth length
2. Pulp length
3. Root length on mesial side
4. Pulp width at level a (cementoenamel junction [CEJ]), level c (midroot level), and level b (midpoint of c and a)
5. Root width at level a (CEI), level c (midroot level), and level b (midpoint of c and a).

In order to reduce the possible effects of variation in magnification and angulations of the radiographs, the following ratios were calculated;

1. Root length/tooth length (T)
2. Pulp length/tooth length (R)
3. Pulp length/root length (P)
4. Pulp width/root width at level a (A)
5. Pulp width/root width at level b (B)
6. Pulp width/root width at level c (C)
7. Mean values of all ratios (M)

All morphological variables and the chronological age of the patient were entered in "MICROSOFT EXCEL" spread sheet for use of age estimation. Age was calculated using the linear regression equation developed by Kvaal et al (1995)11 for mandibular canines.

Age = 158.8 - 255.7(M)

Results

After statistical analysis it was observed that the chronological age average found to be 41.60 years with an age range of 39-47 years in combined population (Table 1). The age range for male was 39-46 years and for females it was 40-47 tears. Whereas estimated age by Cameriere's method was observed to be 43.10 and by Kvaal's method it was found to be 42.78 years. There is

overestimation of age by Cameriere's method by 1.50 years and by Kvaal's by 1.18 years (Table 2 and 3)

When chronological age was correlated with dental age estimated by Cameriere's method and Kvaal's method statistically significant correlation was observed. ($p<0.05$) (Table 4 and 5).

Discussion

The importance of forensic odontology is now increasingly being recognized in the identification of dead as well as in the investigation of various offences, from the likes of dentition, bite marks etc. It is used in forensic archaeology to identify the fossils and interpret their life styles, food habits etc.[5]

Knowing age of unidentified dead person and person in question with a disputed age is of prime importance. Also finding the age at death helps in identifying a dead person[6]. Age estimation narrows down the pool of persons with whom the comparison is to be done for identification.

From infants to young adults the age estimation correlates with the development of dentition as it is more accurate[7]. Dentition has a unique role to play in identifying human remains because of its durability, resilience and stability[7]. Age estimation using ageing changes in different tissues have been done but with constrained results as many get affected by environmental factors[7].

In forensic odontology the radiographs provide vital information which can't be seen on physical examination and it is also a non – destructive method. Comparative study of post-mortem and anti-mortem radiographs along with clinical dental examination make the process of identification less difficult and reliable. Stage of eruption in radiographs also give an idea about the age of an individual[8]. The estimation of age at time of death is often an important step in identification of human remains.[6] If the age can be accurately estimated, it will significantly narrow the field of possible identities that will have to be compared to the remains in order to establish a positive identification.

Some of the more accurate methods of age estimation, in the juvenile and younger adult, have been based on the assessment of the degree of dental development as it relates to chronological age. [9]

Examination of teeth in many ways forms a unique part of human body, as they are most durable and resilient part of the skeleton. The science dealing with establishing identity of a person by teeth is popularly known as Forensic Odontology or Forensic Dentistry.[9]

Changes that are appreciable in teeth with increasing age are attrition, periodontal disease, and deposition of secondary dentine, root translucency, cementum apposition, root resorption, color changes and increase in root roughness. By taking into consideration, these secondary changes in teeth with advancing age, various studies were done to estimate the age of an individual. Such research has resulted in multifactorial methods that help in age estimation.[9]

The age related changes in the dentition could be divided into three categories, formative, degenerative, and histological. 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.[10]

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.[10]

The changes connected with age are the following: [11]

1. Attrition takes place from the wearing down of the incisal or occlusal surfaces due to mastication. This change is seen both macroscopically and microscopically.
2. Periodontitis, loosening of the tooth, or continuous eruption, is characterized by changes in the attachment of the tooth. This change again, is seen both macroscopically and microscopically.
3. Secondary dentin may develop within the pulp cavity; partly as a direct sign of aging and partly as a reaction against pathologic conditions like caries and periodontitis. This change is to be seen only in the microscopic sections.
4. Cementum apposition may take place at the root and around it, particularly in connection with periodontitis. It is seen in microscopic sections only.
5. Root resorption may involve both cementum and dentin.
6. Transparency of the root increases with age and is best appreciated in ground sections.

Radiographs being non-destructive method also play a vital role in forensic dentistry to uncover the hidden facts, which cannot be seen by means of physical examination. Dental examination and comparison between antemortem and postmortem dental records and radiographs produce results with a high degree of reliability and relative simplicity.

Radiographs are also helpful to determine the age of an individual by assessing the stage of eruption.[8]

The present study was designed with the objective of determination of the dental age in an Indore (Madhya Pradesh) population using estimation methods i.e. Cameriere's method which was used on a European. Cameriere et al performed the study in Italian population in 2004. Due to ethnic differences in the two population groups, i.e., the European population and the Indore population, the applicability of the methods was tested.

A sample size consisting of 34 patients from Indore region which were selected randomly having no pathology with the mandibular canine.

The obtained Dental Age in this study in different groups was found to be higher than the chronologic age in both males and females by Cameriere's method.

An average overestimation of 0.84 years in males and 1.52 years in females and 1.30 years in total sample was found by Cameriere's method. In the present study we found the significant correlation between chronological age and estimated age by Cameriere's method and was statistically significant for combined sample i.e. $p<0.01$, $r=0.422$ by Cameriere's method. This was in accordance to the previous studies conducted by Cameriere et al (2004)[12,13] and N.Bosmans et al (2004)[14].

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.

Similarly correlation was found pulp/tooth volume ratio and biological age by Yang Fan et al (2006)[15] and N. Jagannathan et al (2011)[16].

Similarly, the effect of gender on age estimation was also determined in this study, and we found that gender had no significant influence on age. This is in accordance with the original study carried out by Cameriere et al (2004)[12,13].

Babshet et al (2010)[17] applied the formula reported by Cameriere et al (2007)[18] and the modified Indian formula in Indian population on mandibular canine and found that the use of population specific formula did not improve age estimation to a great degree and the original Italian formula itself may be used in Indians. Several other Indian and non-European studies have shown

similar results as that of the present study studies[19,20,21,22,23]. The different formulae given by different authors needs to be checked and validated for Indian population in general.

In this study we chose only mandibular canine as the tooth of choice. We would preferably have included molars, but the preliminary study clearly demonstrated that accurate measurements of multi-rooted teeth were difficult to perform, and for the same reason maxillary first premolars, which frequently have two roots, were likewise excluded, and this is one of the major drawback of the study.

Rotated teeth, decayed teeth or teeth with any prosthetic fitting were excluded from the study. If the individual has any of the mentioned conditions, then this method cannot be employed to estimate the age, as these conditions alter the tooth surface area.

Some questions concerning precision and accuracy of the measurements have been reported in literature when using digital measurements. So in future, image analysis programs which can recognize pulp outlines in a radiographic image could be developed, which will be very useful in minimizing human manual measurements of morphological parameters, and will probably reduce both inter- and intra-observer variability.

As discussed earlier, the effect of distortion of the radiographic image on age estimation is to be seen. Therefore, in future, studies can be taken up to see the effect of distortion on age estimation. Selecting two different single rooted teeth on a same radiograph for calculating the age, and then comparing the two readings can help in determining the same.

Conclusion

The study can be carried forward with a larger sample size to validate the Cameriere's formula and Kvaal's formula as the pilot study shows promising results with the same. To increase the accuracy automated software can be used for eliminating the observer's bias on anatomy of tooth.

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Legend Tables and Figures

Table 1: Distribution of subjects according to age range and sex

Samples	No of samples	Age Range
Males	10	39-46 years
Females	20	40-47 years
Total	30	39-47 years

Table 2: Comparison of Chronological with Estimated Age by Cameriere's method & Kvaal's method and Anova test

age				
N=30	Mean SD	Std. Deviation	Std. Error	Anova Between groups (significance)
Chronological Age	41.60	1.90	0.34	0.145
Estimated age by Cameriere Method	43.10	4.18	0.76	
Estimated age by Kvaal's Method	42.78	2.74	0.50	

Table 3: Multiple comparison of Chronological with Estimated Age by Cameriere's method & Kvaal's method

Tukey HSD	groups	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Chronological Age	Estimated age by Cameriere Method	-1.50	0.79	.149	-3.40	0.39
	Estimated age by Kvaal's Method	-1.18	0.79	.303	-3.08	0.71
Estimated age by Cameriere Method	Estimated age by Kvaal's Method	0.31	0.79	.916	-1.58	2.22

Table 4: Group wise comparison of the chroological age with estimated age by Cameriere's method and Kvaal's method

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Comparison of chronological age and estimated age by Camerirre's method	Equal variances assumed	7.69	.007	-1.79	58	.078	-1.50
Comparison of chronological age and estimated age by Kvaal's method	Equal variances assumed	1.53	.220	-1.94	58	.057	-1.18

Table 5: Correlation of the chronological age with estimated age by Cameriere's method and Kvaal's method

Correlations				
		Chronological Age	Estimated age by Cameriere Method	Estimated age by Kvaal's Method
Chronological Age	Pearson Correlation	1	.438*	.672**
	Sig. (2-tailed)		.016	.000
	N	30	30	30
Estimated age by Cameriere Method	Pearson Correlation	.438*	1	.396*
	Sig. (2-tailed)	.016		.030
	N	30	30	30
Estimated age by Kvaal's Method	Pearson Correlation	.672**	.396*	1
	Sig. (2-tailed)	.000	.030	
	N	30	30	30
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

Figure 1: The area of pulp (a) and mandibular canine(b) is traced in the image morphometric software.

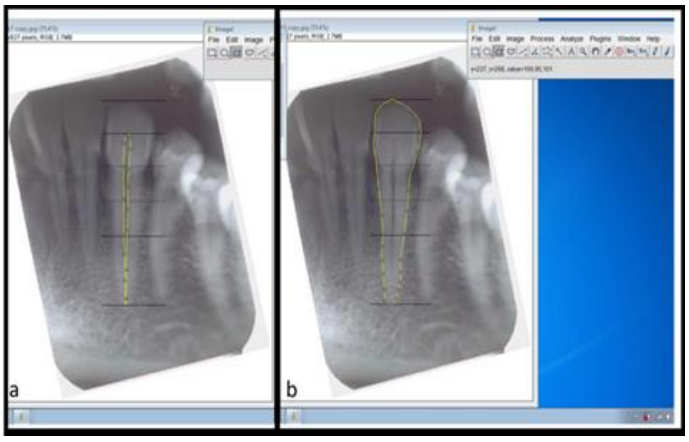

Figure 2: The dimensions of the tooth at different regions according to Kvaal's criteria are measured in the image morphometric software.