



**Research Article**

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## Assessment of pulp- tooth length ratio in forensic age estimation

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### Abstract

**Background:** Among various essential factors given for establishing the identity of the person, age is of utmost importance. Age estimation is a process of particular interest adopted by Anthropologist, Archaeologists & Forensic scientists in order to identify a person who is dead/missing/living. Various studies and techniques have been documented for age estimation, each one demonstrating various degrees of accuracy, reliability & precision. Among various methods of age estimation, teeth are frequently used for the same as they may be preserved for a long time even after all other tissues have disintegrated. **Aim:** This study aims to present a method for assessing the chronological age of an individual by correlating the relationship between age and pulp /tooth length ratio in mandibular canine. **Materials and Methods:** In the present study, 60 extracted permanent mandibular canines were included from individuals with known age (between the age group of 15-70 yrs) and sex. The sample were subdivided into 6 groups based on the age of the individual with 10 samples in each group. The measurement was done by unsectioned method to measure the pulp tooth length ratio. Maximum tooth length was measured with a pair of digital Vernier Caliper and Maximum pulp length by endodontic K-file. Data obtained was tabulated and statistically analyzed using One-way ANOVA test for continuous variables and unpaired t test for categorical variables. **Results:** There was significant difference for all the study variables like (pulp: tooth length ratio) across different age groups. However, there was no significant difference in the study variables between the genders. A gradual reduction in pulp size was observed with respect to total pulp length and cervical pulp width with an increase in age and this showed a significant correlation with the chronological age. **Conclusion:** Dental age prediction is useful in routine and mass fatalities as teeth can be preserved for a long time. The results and observations obtained from the present study indicate that with advancing age, the length of the dental pulp chamber decreases vertically as well as horizontally as a result of secondary dentin deposition. However, these variables could not differentiate between the genders. Thus, assessment of pulp/tooth length ratio on mandibular canine using odontometric procedure manually without any sophisticated instruments can be used as an alternative method to estimate the nearest chronological age with reasonable accuracy when radiographs are not available.

**Keywords:** Age estimation, pulp-tooth length, Forensic science, Identification, Mandibular canine.

### INTRODUCTION

Positive identification in forensic identification relies on multidisciplinary team effort as well as methodologies which may be presumptive or exclusionary<sup>[1]</sup>. Few of the essential factors in establishing the identity of the person are age, sex, race, ethnicity of an individual usually adopted by Anthropologist, Forensic scientists and Archeologists on both living and/or dead<sup>[2]</sup>. Universally, things which may be natural or artificial can be dated, numbered, quantified and/ or measured. For centuries the concept of time has been dealt by human beings. Life span of an individual has been measured since ages from the days of conception<sup>[3]</sup>.

The most critical part in victim identification process is age estimation, especially necessary in cases of unidentified dead bodies, in cases where ante-mortem information is unavailable and where personal profile has to be recreated. In addition, age estimation is also done in archaeological specimens dating back to thousands of years.<sup>[4]</sup> In every discipline, there is a need to develop scientific evidence regarding

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Identification based on relevance, reliability and acceptance.<sup>[5]</sup>

Teeth are major sources of evidence for civil and medico legal identification, as they are hardest, most durable part of the human body, they are least affected by the environmental degradation like bacterial decomposition, and can withstand various environmental changes and insults for long time when the rest of the body is damaged beyond recognition<sup>[6]</sup>. Hence teeth are reckoned as one of the reliable methods of the personal identification methods used in forensic sciences<sup>[6,7]</sup>. The scientific literature consists of numerous studies on age estimation carrying varying degrees of accuracy, reliability and precision. The reproducibility and reliability of these study results are possible when the most appropriate methods in each case are properly utilized in practice. Therefore, if the age of an individual is accurately estimated, it will narrow the necessity for possible identities significantly so that the remains can be compared for establishing a positive identification.

This study aims to present a method for assessing the chronological age of an individual by correlating the relationship between age and pulp /tooth length ratio in mandibular canine teeth using odontometric measurements by visual and non destructive methods. Thus, can be used as an alternative method to estimate the nearest chronological dental age with reasonable accuracy even when radiographs are not available as an option.

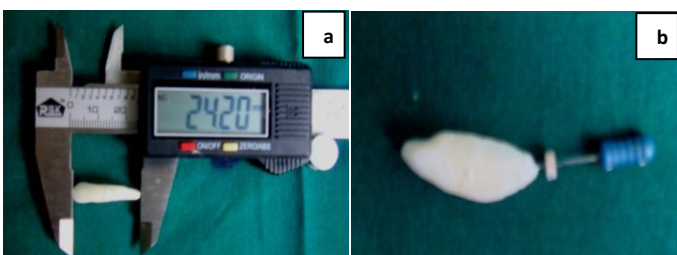
## MATERIALS AND METHOD

### Radiographic assessment

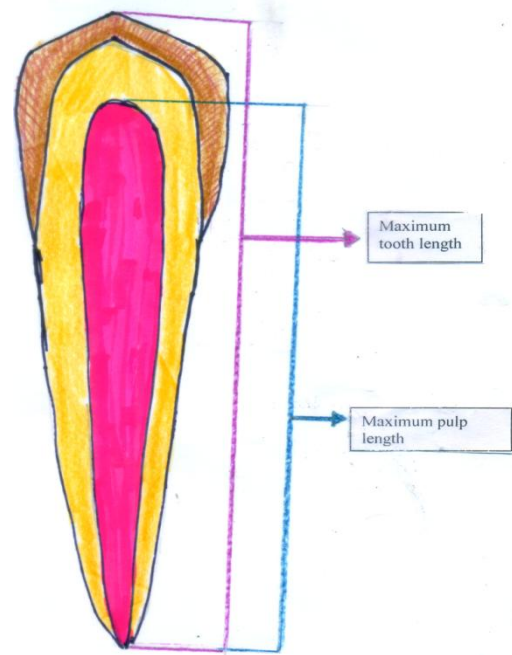
In this study 60 extracted permanent mandibular canines with known age (between the age group of 15-70 years) and sex were collected from dental practitioners of Mangalore. The samples were subdivided into 6 groups based on the age of the individual with 10 samples in each group.

All teeth were obtained from coastal Karnataka population accompanied by a case record stating the ethnicity and age of the patients and no specimens from other population were included. The teeth were washed under tap water immediately after extraction and immersed in 2.5 % sodium hypochlorite for about 30 minutes for removal of any adherent soft tissue. They were then stored individually in 10% formalin with the name and age of the patient until the time of investigation.

Morphologically sound teeth with full formed root were included in the study. Decayed teeth, teeth with restorations, excessive wear and development defects were grouped under exclusion criteria. The measurement was carried out without sectioning the tooth. Tooth length was measured with a pair of digital Vernier Calipers and was calculated from the cusp tip to the root end [Figure 1a]. Pulp length was measured by passing a endodontic K-file through the apical foramen till the point where it cannot be pushed further and marked by rubber stopper [Figure 1b]. The K-file was then removed and the pulp length was measured using Digital Vernier Caliper. Parameters collected were [Figure 2]:-Maximum tooth length, Maximum pulp length.



**Figure 1:** (a) Digital vernier calliper, used to measure Maximum tooth length. (b) K-File, used to measure Maximum pulp length.



**Figure 2:** Diagrammatic representation showing the Maximum Tooth Length, Maximum Pulp Length

### Statistical analysis

The data was statistically analyzed using the SPSS version 16.0 software. Descriptive statistical analysis (Mean and Standard deviation) has been carried out in the present study. Significance has been assessed at 5 % level of significance. To find the significance of study variables across the various age groups, Analysis of variance (ANOVA) was used. Unpaired t test was used to analyze the significance of study variables across the genders. Pearson's correlation and simple linear regression was carried out for the significant variables.

## RESULTS

The sample consisted of 60 freshly extracted mandibular canines that were stored in formalin. The teeth were categorized based on the patients' age (Table 1). Each category consisted of 10 teeth. Group I: 15 – 20 years, Group II: 21 – 30 years, Group III: 31 – 40 years, Group IV: 41 – 50 years Group V: 51 – 60 years, Group VI: >60 years .

The mean pulp length tooth length ratio was found to be 0.85+0.012 for 15-20 years, 0.85+0.017 for 21-30 years, 0.85+0.010 for 31-40 years, 0.79+0.059 for 41-50 years, 0.74+0.065 for 51-60 years, 0.77+0.056 for > 60 years (Table 3). There was a statistical significance difference seen between the various age groups (Table 4).

Of the 60 teeth that were obtained, 31 were of males (51.7%) and 29 were of females (48.3%) (Table 2). The mean pulp length tooth length ratio was found to be 0.79+0.06 for males and 0.82+0.06 for females (Table 5). However, there were no significant gender differences in the present study ( $r = 0.244$ ,  $P > 0.05$ , not significant) (Table 5,7).

Pearson's correlation value of  $r = -0.663$  showed a statistically significant correlation between age and pulp: tooth length ratio ( $P < 0.01$ ), which was highly significant (Table 6).

Pearson's correlation of the study variables with gender. With the value of  $r = 0.226$  along with  $P > 0.05$ , (not significant) suggested that there was no correlation between pulp: tooth length ratio  $P > 0.05$  and gender (Table 7).

**Table 1:** Distribution of the sample based on the different age groups

		Frequency	Percent
Valid	15-20 yrs	10	16.7
	21-30yrs	10	16.7
	31-40 yrs	10	16.7
	41-50 yrs	10	16.7
	51 - 60 yrs	10	16.7
	> 60 yrs	10	16.7
	Total	60	100.0

**Table 2:** Gender distribution of the sample

		Frequency	Percent
Valid	Male	31	51.7
	Female	29	48.3
	Total	60	100.0

**Table 3:** Descriptive statistics of the study variables across the various age groups

	Age group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
						Pulp length: tooth length ratio	15-20 yrs		
	21-30yrs	10	0.8550	0.01780	0.00563	0.8423	0.8677	0.83	0.88
	31-40 yrs	10	0.8450	0.01080	0.00342	0.8373	0.8527	0.83	0.86
	41-50 yrs	10	0.7980	0.05884	0.01861	0.7559	0.8401	0.67	0.87
	51 - 60 yrs	10	0.7440	0.06535	0.02067	0.6972	0.7908	0.63	0.82
	> 60 yrs	10	0.7690	0.05547	0.01754	0.7293	0.8087	0.68	0.87
	Total	60	0.8115	0.06103	0.00788	0.7957	0.8273	0.63	0.88

**Table 4:** Significance of variables across various age groups using one way ANOVA test

Study variable		Sum of Squares	df	Mean Square	F	p value
Pulp length: Tooth length ratio	Between Groups	0.117	5	0.023	12.344	0.001*
	Within Groups	0.103	54	0.002		
	Total	0.220	59			

(\* p&lt;0.001, very highly significant)

**Table 5:** Significance of variables across genders using unpaired t-test

		N	Mean	Standard Deviation	Std. Error Mean	t	df	t-test for Equality of Means				
								Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
											Lower	Upper
Pulp length: Tooth length ratio	Male	31	.7971	.06304	.01132	-1.915	58	.060	-.02945	.01538	-.06025	.00134
	Female	29	.8266	.05557	.01032							

**Table 6:** Correlation of the study variables with age

		Age
Pulp length: Tooth length ratio	Pearson Correlation	-0.663**
	Sig. (2-tailed)	0.000
	N	60

\*\* . Correlation is significant at the 0.01 level (2-tailed).

**Table 7:** Correlation of the study variables with gender

		Gender
Pulp length: Tooth length ratio	Pearson Correlation	0.244
	Sig. (2-tailed)	0.060
	N	60

## DISCUSSION

The most important age associated change along internal tooth surfaces is secondary dentine deposition which can be usually considered to be well protected against environmental adversities. The assessment of pulp/tooth length ratio is a method which indirectly quantifies secondary dentine deposition. Unlike pulp/tooth area ratio which is a radiographic assessment, our method is performed directly on teeth. Consequently, evaluation of this parameter is an advantage as it has the potential to eliminate at least part of the effects of external factors which may cause external destruction of tooth structure [8]. Hence, among the adults as a result of age related changes, age estimations become considerably more diverse and definite.

Nevertheless, variety of invasive and non invasive method has been developed to estimate the age in adults and children, living or dead. However most of the procedures are invasive and require extraction of teeth which is not possible in the living. Other methods employ the use of non-invasive methods like radiographs [9-11].

The simplest among them is the "visual method" which is based on clinical experience without using formal methods. Formal methods of calculation are based on morph metric measurements and molecular methods like amino acid racemization. The morphometric methods requires to be validated in independent material set or to be formally compared to each other [12]. Many morphometric methods employ the use of radiographs in their estimation. The latter method requires biochemistry laboratory and experience. It is also time consuming, costly and destructive. Our method does not involves radiographs or sophisticated laboratory experience. Hence, it is more user friendly, cost effective and can be used in adverse conditions during victim identification or dental profiling.

In addition, the teeth selected in this study were mandibular canine. Canine was chosen as they have the longest functional survival rate in the mouth, undergo less wear than posterior teeth, are the single root teeth with the largest pulp area and thus easy to analyze. The selected canine was also from non carious teeth since carious lesions lead to the formation of tertiary dentin in the internal walls of the pulpal chambers, conferring a wider thickness of dentin in the area. So the purpose of selecting canines is to obtain values of dentine formed physiologically by dental aging process of the canines. The surface analysis is carried out where the abrasion stimuli, which leads to formation of tertiary dentine, were excluded. In addition Canines were known to give best coefficient as compared to other teeth as per study done by R Cameriere 2009 and also highly valuable in identification [13].

In the past conventional radiographs like periapical and panoramic radiographs have been used to assess the pulp/tooth area ratio of

maxillary canines [14,15]. The primary disadvantage of radiographs is that they are two-dimensional projections which are subjected to considerable magnification and distortional errors. Therefore, a simultaneous assessment of the mesio-distal and bucco-lingual dimensions of teeth has been recommended. Computed tomography (CT) is the ideal and most accurate method to evaluate the pulp/tooth volume ratio [15]. But the disadvantages associated with CT are that it is not accessible to all the cases when and where there is requirement for age estimation. Also the CT is more expensive method, higher radiation exposure and cannot be used for single tooth evaluation. In any method, the accuracy of these dental methods of age estimation should be verified by conducting studies in different populations.

Cameriere *et al.* have conducted numerous studies to quantify the apposition of secondary dentine using the pulp/tooth area ratio on different teeth for age estimation [14]. Their method employs histopathological and/or radiological examination. Hence is time consuming and requires instruments respective to the procedure. Our present study estimates age in a simpler way without destruction of the teeth as well as any sophisticated instruments other than the use of vernier calipers.

Another earlier report by Babshet et al on Italian population for the purpose of age estimate using pulp/tooth area ratio stated that the formula derived could be applied for Indian population as well [16,17]. However, we infer that a formula devised for a particular population may not be applicable in another set of population due to variations in demographic and anthropological details. It may also be due to inter-observer variation in pulp/tooth area calculated from radiographs [8]. Hence our study has the advantage of direct measurement on teeth without much leeway for bias as seen when measuring from a radiograph.

The observations obtained from the current study indicate that with progressing age, the size of the dental pulp chamber is reduced vertically as a result of secondary dentin deposition. However, these findings could not be gender matched. Thus, assessment of pulp /tooth length ratio on mandibular canine using odontometric method can be used as an alternative and cost effective method to estimate the nearest chronological age with reasonable accuracy when radiographs or microscopes are not available.

## CONCLUSION

Dental age prediction is useful in routine and mass fatalities as teeth can be preserved for a long time. The present work showed that assessing the chronological age of an individual by correlating the relationship between age and pulp /tooth length ratio in mandibular canine by using odontometric measurements with visual and non destructive methods, acceptable age predictions can be made possible for the Indian population. However, caution should be exercised when

extrapolating these results to practical applications. Further research should be conducted on different types of teeth, of different population which could possibly enhance age prediction.

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