

THICKNESS OF THE DENTAL (RADICULAR) CEMENTUM: A PARAMETER FOR ESTIMATING AGE

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ABSTRACT

The present study used 127 extracted teeth from people aged 16 to 90 years old. The aim of this research was to verify the reliability of the method using a single dental parameter based on the correlation of the radicular cementum thickness and the chronological age of the subject. The thickness was measured both on the lingual side and on the vestibular side of the tooth, at two different levels: apex and one third of the root length from the apex. The data were reported through a Cartesian graph with the X-axis showing the cementum thickness and the Y-axis showing the subject's age. The correlation between age and the increase of the cementum thickness is more statistically evident when the measurement is taken at the apex ($R^2=0.67$), in comparison with the measurement taken at approximately one third of the root length from the apex ($R^2=0.56$).

(J Forensic Odontostomatol 2007;25:1-6)

Key words: dental, cementum thickness, age estimation, identification

INTRODUCTION

The importance of using dental methods to identify unknown cadavers is well known, so the role of histological modifications of the teeth is relevant in ageing. Many different methods have been studied and proposed for ageing unknown deceased people.¹⁻²³ The cementum increase represents the most relevant way of exhibiting histological modification that occurs to the teeth during the subject's life.^{24,25}

Many authors have described the contribution and importance of the cementum in studies that use one or multiple dental parameters.²⁶⁻²⁸ The aim of this research was to verify the reliability of the method using a single parameter based on the correlation of

the radicular cementum thickness and the chronological age of the subject.^{29,30}

MATERIALS AND METHODS

The present study used 127 teeth, extracted from different individuals involving both sexes (67 females and 60 males) and various ages (range from 16 to 90 years old). The dental samples were collected in a general dental surgery, subsequent to clinical dental treatment planning for various conditions (mostly periodontal pathologies or orthodontic therapy).³¹ None of the samples presented fillings or endodontic treatments. After the teeth were extracted, they were washed using only running water. Detergents and disinfectants were not used since they may alter the histological characteristics. A diamond cutter was used to mark the vestibular side of the tooth. The teeth were stored in rigid containers filled with a decalcification solution for an average of 15 days (minimum 10 maximum 25). The decalcification time depends on the size of the teeth: about 10 days for the smaller teeth including incisors and about 15 days for the molars. After decalcification, the samples were removed from the liquid and placed in paraffin wax. Using a microtome, sections were cut longitudinally at a thickness of 5 micron, in lingual-vestibular direction, passing through the radicular apex. Since some multi-radicular samples present difficulties in cutting due to the natural curve of the roots, a section of each root was prepared; the section was chosen based on the best visualization of the apex. Sections were then coloured with a hematoxylin-eosin stain and observed through an optical microscope equipped with an eyepiece micrometer magnification X4.*

The thickness was measured both on the lingual side and on the vestibular side, at two different levels at the apex and at the one third of the root length from

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the apex. Using methods described by Solheim,⁸ these measurements were labelled as follows:

- C1: lingual side, at one third of the root length from the apex;
- C2: vestibular side, at one third of the root length from the apex;
- C3: lingual side, at the apex;
- C4: vestibular side, at the apex.

Data were reported through a Cartesian graph with the X-axis showing the cementum's thickness and the Y-axis showing the subject's age. Using standard descriptive statistical methods of linear regression, the data were inserted into the regression formula to obtain the predicted age.³² The regression model (3rd degree polynomial) seemed to give approximate reliable data to describe a plausible mathematical correlation between the cementum thickness and age. The model provided a two-fold analysis: descriptive-explanatory and predictive. The descriptive-explanatory analysis examined the correlation between Y (age) and X (thickness). The predictive analysis targeted predicting the chronological age of the subject, when the cementum thickness is known. Since there is a difference in the mean thickness value at the two levels (the cementum thickness at the apex is usually the thickest) the analysis was conducted by separating the measurements at the C1-C2 level and those at the C3-C4 level.

RESULTS

To obtain a regression equation^{33,34} using all of the collected samples, we first calculated the average value of cementum thickness at the C3-C4 level

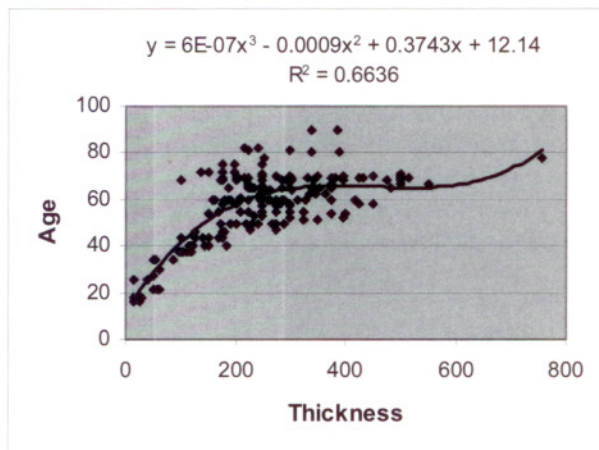


Fig.1: Relationship of chronological age and cementum's thickness at the apex

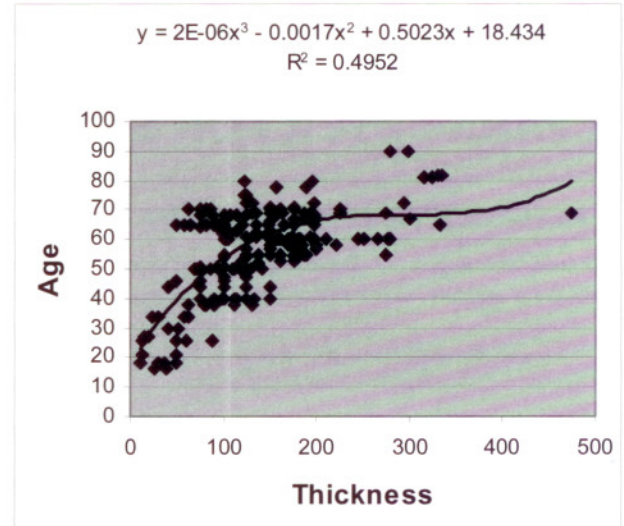


Fig.2: Relationship of chronological age and cementum's thickness at the C1-C2

($\bar{x} = 243.7$) and the mean age of subjects

($\bar{y} = 57.2$), then we mathematically minimized the distance of data points from the 3rd degree equation, obtaining the following equation:

$y = 6 \cdot 10^{-7} \cdot x^3 - 0.0009 \cdot x^2 + 0.3743 \cdot x + 12.14$
with $R^2=0.66$ while the correlation coefficient of Bravais-Pearson (r) was 0.68.

The estimated age for the average thickness value ($x = \bar{x}$) resulted equal to 58.6 years \pm 1.49 years with the range of the reliability at 95%. Fig.1 shows data from the entire sample at the apical position (C3,C4). The variation of the confidence interval depending on the average deviation is shown in Table 1.

Similar analytical procedures were applied to the values obtained at one third of the root length from the apex. From the 254 measurements at this level, the following regression equation was obtained:

$y = 2 \cdot 10^{-6} \cdot x^3 - 0.0017 \cdot x^2 + 0.5023 \cdot x + 18.434$
with $R^2=0.49$.

Figure 2 shows data from the entire sample at one third of the root length from the apex (C1,C2). In Table 2 the values of the confidence intervals are reported in relationship to the average deviation ($\bar{x} = 134.6$) obtaining a determination coefficient of the Bravais-Pearson formula equal to 0.61. Similarly,

Table 1: The confidential interval and limits of reliability at the C2-C4

Average disparity	Estimated Age	Range of reliability interval	Range of age
0	58.6	1.49	57.1-60.1
100	58.8	1.71	57.1-60.5
-100	49.1	1.71	47.4-50.8
200	53.4	2.24	51.2-55.7
-200	26.8	2.24	24.6-29.1

Table 2: The interval of reliability and limits of reliability at C1-C2

Average disparity	Estimated Age	Range of reliability interval	Range of age
0	47.7	1.62	54.1-57.3
100	45.3	2.40	42.9-47.7
-100	33.8	2.40	31.4-36.2
134.6	34.4	2.89	31.5-37.2
-134.6	18.4	2.89	15.5-21.3

the same procedure was individually applied to each type of the dental samples (see Table 3).

Incisors

Forty two incisors were analysed (168 measurements), 16 mandibular incisors and 26 maxillary incisors. The correlation values are rather satisfactory for the C1-C2 incisors measurements of both arches and for the C3-C4 values in the upper incisors. On the contrary the correlation index is meaningless in reference to measurements of the lower incisors at the apex (C3-C4).

Canines

Thirty two canines were analysed (128 measurements), 14 lower canines and 18 upper canines. Both the upper canines' measurements and lower canines' apical measurements demonstrated to be reliable enough for showing a correlation. The measurements of the lower canines at C1-C2 level did not show a strong correlation with age.

Premolars

Fifteen premolars were analysed (60 measurements), 6 lower and 9 upper in total. The upper premolars at the two different root levels and lower premolars at C1-C2, showed a good correlation between the cementum thickness and age factor.

Table 3: 3rd degree equation, correlation coefficient (R), determination coefficient (R²) for each kind of tooth

			Equation	r	R ²
Incisor	up	ap	$y = -9E-07x^3 + 0.0005x^2 + 0.0424x + 36.583$	0.53	0.43
		mid	$y = -5E-07x^3 + 0.0002x^2 + 0.1224x + 40.89$	0.60	0.36
	low	ap	$y = 3E-06x^3 - 0.0027x^2 + 0.8542x - 20.582$	0.09	0.07
		mid	$y = -3E-07x^3 + 0.0006x^2 - 0.1554x + 71.473$	0.47	0.45
Canine	up	ap	$y = 2E-06x^3 - 0.0017x^2 + 0.5735x - 0.7459$	0.58	0.59
		mid	$y = 2E-05x^3 - 0.0107x^2 + 1.6687x - 27.237$	0.58	0.49
	low	ap	$y = 9E-07x^3 - 0.0011x^2 + 0.4679x + 3.2203$	0.65	0.64
		mid	$y = -1E-05x^3 + 0.0065x^2 - 0.8259x + 91.051$	0.18	0.16
Premolar	up	ap	$y = 1E-07x^3 - 0.0006x^2 + 0.3641x + 8.3435$	0.85	0.88
		mid	$y = -6E-07x^3 - 0.002x^2 + 0.759x - 4.2603$	0.84	0.76
	low	ap	$y = -2E-05x^3 + 0.0204x^2 - 6.1736x + 659.47$	0.47	0.42
		mid	$y = -6E-05x^3 + 0.0338x^2 - 6.6545x + 483.32$	0.84	0.76
Molar	up	ap	$y = 3E-06x^3 - 0.0024x^2 + 0.6656x + 2.265$	0.53	0.47
		mid	$y = 3E-07x^3 - 0.0006x^2 + 0.2764x + 31.659$	0.61	0.51
	low	ap	$y = -3E-06x^3 + 0.0025x^2 - 0.4955x + 72.982$	0.70	0.69
		mid	$y = 9E-06x^3 - 0.0035x^2 + 0.433x + 37.401$	0.26	0.12
Third Molar	up	ap	$y = -7E-07x^3 + 0.0003x^2 + 0.0664x + 25.076$	0.98	0.99
		mid	$y = -5E-05x^3 + 0.011x^2 - 0.4821x + 30.786$	0.95	0.98
	low	ap	$y = -0.0008x^3 + 0.0906x^2 - 2.8602x + 45.677$	0.33	0.22
		mid	$y = 0.0003x^3 - 0.0465x^2 + 1.897x + 5.1987$	0.05	0.32

Molars

Sixteen molars were analysed (64 measurements), 6 mandibular and 10 maxillary samples. The prediction of the molars demonstrated fairly satisfactory results for the maxillary samples and the lower at C3-C4. It was determined to be less reliable for the lower at the C1-C2.

Table 4: Average values of the statistical parameters: R , R^2

	r_{av}	R^2_{av}
Upper at C3-C4	0.69	0.67
Upper at C1-C2	0.72	0.62
Lower at C3-C4	0.57	0.56
Lower at C1-C2	0.36	0.36

Table 5: Prediction efficiency of the method considered for the entire sample

	Prediction Affidability		
	< 5 years	< 8 years	< 10 years
C1-C2	28%	51%	64%
C3-C4	37%	58%	71%

Third molars

Twelve third molars were analysed (48 measurements), 7 lower and 5 upper molars. The results from both measurements of the upper third molar demonstrate a determination coefficient at almost 1.0. Despite this excellent result we must note the scarcity of the third molar samples. Whereas, the measurements at both levels of the lower third molar show a very low correlation between cementum thickness and age.

DISCUSSION

The statistical analysis conducted on the variation of the radicular cementum thickness and the age increase suggested an interesting relationship between the two variables. Table 4 shows the average values of the statistic parameters (r , R^2) referring to the different points of measurements. Generally, the correlation between age and the increase of the cementum thickness seems to be more statistically evident when the measurement is taken at the apex ($R^2=0.67$ for the upper at the C3-C4 level and $R^2=0.56$ for the lower at the C3-C4 level), rather than at the one third of the root length from the apex ($R^2=0.62$ for upper at the C1-C2 level and $R^2=0.36$ for lower at the C1-C2). In particular, the different types of teeth samples do not provide the same capacity in predicting age.

The incisors show interesting values of the determination coefficient even if not quite significant, although the measurements taken at the superior level of the upper root and at the lower one third of the root from the apex appear more predictive ($R^2=0.43$ and $R^2=0.45$ respectively) than the other measurements. The canines seem to be slightly better than the incisors in the predictive ability at both levels especially referring to the measurements taken of the upper and lower canines at C3-C4, while the lower canines at the C1-C2 level appear to be not significant for predictive ability ($R^2=0.16$). The upper premolars cementum thickness (at both levels) and the lower premolars at one third of the root from the apex shows a very good correlation with age augmentation ($R^2=0.88$, $R^2=0.76$ and $R^2=0.76$ respectively). We may suppose that such a high determination index is due to the fact that all ages (16 to 70 years) are homogeneously represented in the sample of this kind of tooth. It could be deduced for other teeth samples (i.e. mandibular incisors) the lower value of the determination coefficient is due to the small range of subjects' age in our sample. The molars, like the canines, show a better predictability at the C3-C4 level in the jaw ($R^2=0.69$ at the apex). The relationship between age and cementum thickness for uppers molars appears to be suggestive ($R^2=0.47$ for upper molars at the apex and $R^2=0.51$ for the upper molars at the one third of the root from the apex) but not completely significant. The upper third molars appear to be the most significant tooth in age predicting ($R^2=1$). This interesting result

Table 6: Prediction efficiency for the most significant teeth

	C1-C2		
	<5 years	<8 years	<10 years
Lower incisors	63%	91%	97%
Upper molars	33%	56%	72%
Upper premolars	44%	69%	81%
Upper third molars	60%	90%	100%

	C3-C4		
	<5 years	<8 years	<10 years
Upper incisors	37%	53%	63%
Lower molars	50%	71%	71%
Upper premolars	87%	87%	87%
Upper third molars	100%	100%	100%

should be confirmed on a larger population, since our sample size involving this type of tooth was distributed on a small age range; furthermore, the results for the lower third molar are not significant.

An additional consideration emerged from all of the dental samples used (see Table 4): the upper teeth were found to be significantly more reliable than lower teeth. The statistic model that we used (3rd degree polynomial) proved a good correspondence between the experimental and the theoretical data. Thus, the findings conclude a good estimate of the subject's age can be determined by cementum's thickness measurements, even if the subject is less than 25 years old since these findings are slightly overestimated.³⁵

Finally, the observation pointed out from Table 5 is very interesting and indicative of the efficiency of the method we used. This table shows the probability of having a good estimate of the age through measuring the tooth (upper and lower level) at the apex and at the one third of the root length from the apex (C1-C2-C3-C4). These proportions are better if the tooth used is the upper molar and/or the upper third molar. In Table 6 the prediction efficiency is shown only for the most significant teeth.

We must note that this kind of approach needs further study by increasing the sample population size and the age range diversity to be considered reliable.

CONCLUSION

The histological method and the statistical tools presented in the study respect all scientific methods including objectivity, repeatability, verification, elaboration, and interpretation of data. Furthermore, the used method was especially simple due to standard laboratory instruments, which reduced work hours in comparison with methods that do not use non-calcified dental samples. It is important to consider the gains in using standard forensic practices on a daily basis to conduct histological procedures and statistical foresight of age in a low cost way such as in this study. The results are seemingly satisfactory and reliable and can be utilized as a helpful age estimation tool.

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