A REVIEW OF THE MOST COMMONLY USED DENTAL AGE ESTIMATION TECHNIQUES

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ABSTRACT

This review of literature provides an overview of the most commonly used dental age estimation techniques and focuses on dental age estimation scoring systems in children and adults. In order to obtain a more reliable and reproducible age estimation the forensic odontologist should use several of these available methods whenever an age estimation in the living or dead is required. **(J Forensic Odontostomatol 2001;19:9-17)**

Key words: Dental age estimation, forensic odontology

INTRODUCTION

Age estimation is a sub-discipline of the forensic sciences and should be an important part of every identification process, especially when information relating to the deceased is unavailable. The estimation should be as accurate as possible since it narrows down the search within the police Missing Persons files and enables a more efficient and time saving approach. Age estimation is of broader importance in forensic medicine, not only for identification purposes of deceased victims, but also in connection with crimes and accidents. In addition, chronological age is important in most societies for school attendance, social benefits, employment and marriage.

Dental maturity has played an important role in estimating the chronological age of individuals because of the reported low variability of dental indicators. Techniques for chronological age estimation in children based on dental maturation may be divided into those using the atlas approach and those using scoring systems whereas in adults there are the morphological and radiological techniques.

Dental age estimation in children

(a) Atlas approach

The use of radiographs is characteristic of techniques using the atlas approach where the morphologically distinct stages of mineralization that all teeth share are observed. Compared to bone mineralization, tooth mineralization stages are much less affected by variation in nutritional and endocrine status and developing teeth therefore provide a more accurate indication of chronological age.

The Tables of Schour and Massler[1] have become a classic example of an atlas approach. They described about 20 chronological stages of dental development starting from 4 months after birth until 21 years-of-age and comparing an individual's dental development with these tables can result in a useful estimation of the chronological age.

Moorrees *et al.*[2] divided dental maturation of the permanent dentition into 14 different stages ranging from "initial cusp formation" up to "apical closure complete" and designed different tables for males and females. For each tooth an estimation of chronological age can be read from these tables based on the mineralization and stage of development of that specific tooth.

Anderson *et al.*[3] further developed the system of Moorrees *et al.*[2] for all the teeth including the third molars. The Tables they compiled[3] are considered very comprehensive and can be applied to a much larger age range of juveniles.

(b) Scoring system

Demirjian *et al.*[4,5] tried to simplify chronological age estimation and restricted the number of stages of tooth development to 8 giving them a score of 'A' through 'H' (Fig.1) and confined the analysis to the first seven teeth of the left lower quadrant. Based on statistical analysis they were able to assign a maturity score for each of these seven teeth to almost each of the 8 developmental stages and differentiated for boys and girls as can be seen in Tables 1 and 2.[4] Finally, adding these 8 scores results in an overall maturity score that leads to an estimation of chronological age (Table 3 and 4).[4]

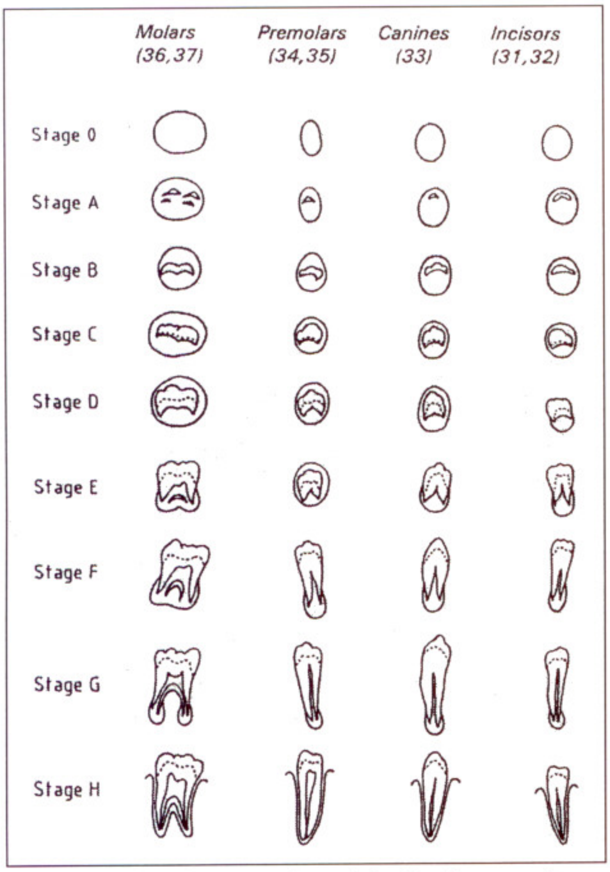

Fig.1: *Graphical presentation of the developmental stages as presented by Demirjian et al.*[4]

Based on several literature reports mentioning a consistent overestimation when using Demirjian's technique[6-9] Willems *et al.*[9-10] repeated Demirijian's study for a Belgian Caucasian population. Statistical analysis of the results led to the creation of new Tables (Tables 5 and 6) for boys and girls with maturity scores expressed in years. Adding the maturity scores for the different teeth directly gives the estimate of the individual's chronological age.

Dental age estimation in adults

Apart from the above mentioned techniques for age estimation in children and young adolescents several methods are described in the literature that address age estimation in adults. Among these techniques are refined and relatively accurate methods, some of which are conservative and do not invade tooth structure.

(a) Morphological techniques

An early age estimation technique was published by Gustafson.[11] It is based on the measurement of regressive changes in teeth such as the amount of occlusal attrition, the amount of coronal secondary dentine formation, the loss of periodontal attachment, the apposition of cementum at the root apex, the amount of apical resorption and the transparency of the root. For each of these parameters Gustafson assigned different scores on a scale from 0 to 3 and by adding these an overall score was obtained which was linearly related to an estimated age. Gustafson's linear regression formula for age estimation was:

Age = 11.43 + 4.56X (Equation 1)

where X equalled the overall score. This technique, which was actually based on a small sample of 40 teeth, has been improved through the years first by Dalitz[12] and then by Johanson.[13] Maples[14] tried to improve Gustafson's estimation method by including a correction factor for tooth position but did not succeed in producing a significantly more accurate technique, despite his multiple regression analysis. Finally Maples and Rice[15] found that Gustafson miscalculated his regression formula and they reported the correction:

Age = 13.45 + 4.26X (Equation 2)

The improvements in the original technique implemented by Johanson[13] are actually the most widely accepted among forensic odontologists. He differentiated between seven different stages instead of the original four and evaluated the same six criteria (Fig.2). In addition, he was able to obtain a multiple regression formula based on these six variables but was not able to differentiate for tooth position.

The following formula[13] may therefore be used for performing an age estimation based on the six criteria mentioned earlier: attrition (A), secondary dentine formation (S), periodontal attachment loss (P), cementum apposition (C), root resorption (R) and apical translucency (T):

Age =11.02 + (5.14*A) + (2.3*S) + (4.14*P) + (3.71*C) + (5.57*R) + (8.98*T) (Equation 3)

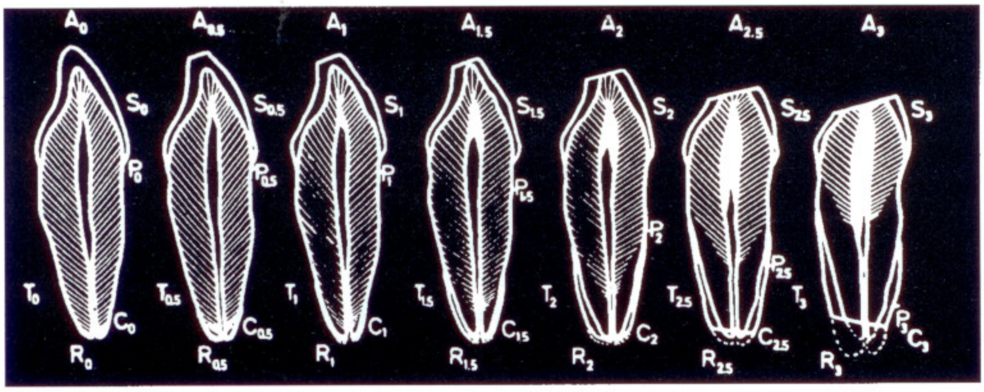

Fig.2: Seven different stages with corresponding scores from 0 to 3 relevant for dental age estimation as reported by Johanson[13]

Earlier in 1970, Bang and Ramm[16] presented a method for age estimation based on the measurement of only one parameter: the length of the apical translucent zone in mm of a given tooth. They differentiated for tooth position, for side and for the kind of tooth substrate that was being used, namely intact tooth versus tooth section. Based on a large sample the authors were able to present a second-degree polynomial regression formula for the estimation of age based on a single measurement on a single tooth:

Age = $B_0 + (B_1*X) + (B_2*X^2)$ (Equation 4)

They further differentiated the age estimation based on the total length of the translucent zone. For translucent zones smaller than or equal to 9 mm equation 4 was used. In case of translucent zones larger than 9 mm a first-degree polynomial regression formula was used:

Age = $B_0 + (B_1*X)$ (Equation 5)

The regression constant and the regression coefficients for the given equations can be found in Table 7. Care has to be taken to look for the corresponding values according to the total length of the translucent zone and the absence or presence of tooth sectioning.

Finally, but certainly not least, in an effort to improve on existing methods or techniques that showed statistical shortcomings or smallness of samples, Solheim[17] reported his technique for dental age estimation in 1993. He measured different parameters related to change over time for over 1000 teeth and for each individual tooth selected those parameters showing the strongest correlation with age. For each individual tooth a multiple regression analysis was run with age as the dependent variable. Since both the gender of the deceased may be unknown and the colour of the tooth may be influenced by post-mortem changes, separate multiple regression analyses were run for each individual tooth including and excluding both parameters. Table 8 shows the multiple regression formulae with age as the dependent variable and the age changes, including colour and gender versus exclusion of colour and gender, as independent variables to be measured. Among the age changes that were evaluated were:

AJ (attrition measured according to Johanson[13]),
ARA (area of attrition on occlusal tooth surface measured in square mm),
C1 (sum of cementum thickness on vestibular + lingual surfaces measured at 1/3 of root length from apex)
CAP (crown pulp area measured in square mm)
CEST (colour estimation of root dentine)
EX3 (tooth extracted for caries or related conditions Yes: score 0 - No: score 1)
LC1 (LOG10[C1])
LPMEAN (log10 PMEAN where PMEAN is the mean periodontal attachment loss in mm of a tooth),
SC (pulp diameter/root diameter at cervical area)
SEX (gender score male: score 0 - female: score 1)
SJ (secondary dentine measured according to Johanson[13])
SRS (surface roughness score)
ST (sum of pulp diameters/sum of root diameters)
TD (translucency of root apex scored according to Dalitz[12])
TID (length in mm of translucent zone in dry intact tooth)

The way in which these age changes are evaluated is described in the articles referred to for each of the measurements and in the work by Solheim.[17]

Special attention should now be drawn to the regression formulae for calculating dental age based on a maxillary central incisor and a mandibular central incisor, both when the independent variables "gender and colour" are excluded. When comparing these formulae in Table 8 with the original reported formulae some small but important corrections brought about by typing errors should be noted. These were actually discovered during a joint pilot study between the author and Solheim[22] during which the original data were statistically recalculated. For the maxillary central incisors the regression constant to be multiplied by C1 should be 0.02 and not 0.2 as originally reported and for the mandibular central incisors 4.6SRS should be added and not subtracted as originally reported.

With respect to the procedures used and the number of teeth included in this major study it is fairly safe to state that the reported formulae are sufficiently reliable to be recommended for age estimation in identification procedures. The fact that some calculations are based on unsectioned tooth measurements makes this technique of particular interest in cases were tooth preservation is necessary.

(b) Radiological techniques

Of additional interest are the following techniques since they are based fully on radiographs and are suitable for age estimations in living persons or where teeth cannot be removed or invaded.

Kvaal *et al.*[18] developed a method for estimating the chronological age of an adult from measurements of the size of the pulp observed on periapical radiographs from six types of teeth: maxillary central and lateral incisor and second bicuspid and mandibular lateral incisor, canine and first bicuspid. The age estimation is based on gender (G) and the calculation of several length and width ratios in order to compensate for magnification and angulation of the original tooth image on the radiograph: pulp/root length (P), pulp/tooth length (R), tooth/root length (T), pulp/root width at cemento-enamel junction (A), pulp/root width at midpoint between level C and A, pulp/root width at midroot length (C), mean value of all ratios excluding T (M), mean value of width ratios B and C (W), mean value of length ratios P and R (L). The results of the regression analyses with age as the dependent variable and the two predictors (M and [W-L]) and gender as independent variables are shown in Table 9. Gender was only included as an independent variable in the formula for the age estimation of the lower lateral incisors because of its higher correlation with age for that specific tooth (male: score 1, female: score 0). The coefficient of determination for the regression also appeared to be the strongest when the ratio for all six types of teeth from both jaws was employed. This coefficient decreased when teeth from only one jaw were included and was the weakest when only mandibular canines were measured.

This method[18] is actually the successor of the following method by Kvaal and Solheim[19] where the former excludes all parameters to be measured on extracted teeth whereas the latter requires an extracted tooth.

Kvaal and Solheim[19] presented a method where radiological and morphological measurements are combined in order to estimate the age of an individual. Depending on the type of tooth present, the following parameters are measured: apical translucency in mm (T), periodontal ligament retraction in mm (P), pulp length measured on radiographs (PL), root length measured on radiographs on mesial surface (RL), pulp width at cemento-enamel junction on radiographs (PWC), root width at cemento-enamel junction on radiographs (RWC), pulp width at midroot on radiographs (PWM), root width at midroot on radiographs (RWM), FL (PL/RL), FWC (PWC/RWC) and FWM (PWM/RWM).

Table 10 shows the multiple regression formulae for age calculation with the size of the pulp chamber on dental radiographs, the periodontal retraction and apical translucency as independent variables. A separate equation is given which excludes apical translucency where applicable.

Finally, when using these techniques in humans the large spread that exists in nature should be taken into account. As far as the methods of dental age estimation in adults are concerned and in view of the relative accuracy of the age estimations performed one should keep in mind that the standard deviations of such age estimations are in general about 10 to 12 years.[20-21]

CONCLUSION

This review of dental age estimation techniques gives an overview of different methods available, all of which have advantages and disadvantages. The most important aspect of dental age estimation for the forensic odontologist to remember is that he or she should not be restricted to only one age estimation technique but to apply the different techniques available and perform repetitive measurements and calculations in order to establish maximum reproducibility. Doing so, it will be possible to provide an age estimation that is as reliable as possible since it was based on a variety of techniques.

	A	B	C	D	E	F	G	H
31				0	1.9	4.1	8.2	11.8
32			0	3.2	5.2	7.8	11.7	13.7
33			0	3.5	7.9	10	11	11.9
34		0	3.4	7	11	12.3	12.7	13.5
35	1.7	3.1	5.4	9.7	12	12.8	13.2	14.4
36			0	8	9.6	12.3	17	19.3
37	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4

Table 1: *Individual maturity scores for boys for each of the developmental stages as reported by Demirjian et al.*[4]

	A	B	C	D	E	F	G	H
31				0	2.4	5.1	9.3	12.9
32			0	3.2	5.6	8.0	12.2	14.2
33			0	3.8	7.3	10.3	11.6	12.4
34		0	3.7	7.5	11.8	13.1	13.4	14.1
35	1.8	3.4	6.5	10.6	12.7	13.5	13.8	14.6
36			0	4.5	6.2	9.0	14.0	16.2
37	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6

Table 2: *Individual maturity scores for girls for each of the developmental stages as reported by Demirjian et al.*[4]

Age	score	Age	score	Age	score	Age	score	Age	score
3	12.4	5.6	30.3	8.2	75.1	10.8	91.6	13.4	96
3.1	12.9	5.7	31.1	8.3	76.4	10.9	91.8	13.5	96.1
3.2	13.5	5.8	31.8	8.4	77.7	11	92	13.6	96.2
3.3	14	5.9	32.6	8.5	79	11.1	92.2	13.7	96.3
3.4	14.5	6	33.6	8.6	80.2	11.2	92.5	13.8	96.4
3.5	15	6.1	34.7	8.7	81.2	11.3	92.7	13.9	96.5
3.6	15.6	6.2	35.8	8.8	82	11.4	92.9	14	96.6
3.7	16.2	6.3	36.9	8.9	82.8	11.5	93.1	14.1	96.7
3.8	17	6.4	39	9	83.6	11.6	93.3	14.2	96.8
3.9	17.6	6.5	39.2	9.1	84.3	11.7	93.5	14.3	96.9
4	18.2	6.6	40.6	9.2	85	11.8	93.7	14.4	97
4.1	18.9	6.7	42	9.3	85.6	11.9	93.9	14.5	97.1
4.2	19.7	6.8	43.6	9.4	86.2	12	94	14.6	97.2
4.3	20.4	6.9	45	9.5	86.7	12.1	94.2	14.7	97.3
4.4	21	7	46	9.6	87.2	12.2	94.4	14.8	97.4
4.5	21.7	7.1	48.3	9.7	87.7	12.3	94.5	14.9	97.5
4.6	22.4	7.2	50	9.8	88.2	12.4	94.6	15	97.6
4.7	23.1	7.3	52	9.9	88.6	12.5	94.8	15.1	97.7
4.8	23.8	7.4	54.3	10	89	12.6	95	15.2	97.8
4.9	24.6	7.5	56.8	10.1	89.3	12.7	95.1	15.3	97.8
5	25.4	7.6	59.6	10.2	89.7	12.8	95.2	15.4	97.9
5.1	26.2	7.7	62.5	10.3	90	12.9	95.4	15.5	98
5.2	27	7.8	66	10.4	90.3	13	95.6	15.6	98.1
5.3	27.8	7.9	69	10.5	90.6	13.1	95.7	15.7	98.2
5.4	28.6	8	71.6	10.6	91	13.2	95.8	15.8	98.2
5.5	29.5	8.1	73.5	10.7	91.3	13.3	95.9	15.9	98.3
								16	198.4

Table 3: *Overall maturity scores for boys as reported by Demirjian et al.*[4]

Age	score	Age	score	Age	score	Age	score	Age	score
3	13.7	5.6	34	8.2	81.2	10.8	94	13.4	97.7
3.1	14.4	5.7	35	8.3	82.2	10.9	94.2	13.5	97.8
3.2	15.1	5.8	36	8.4	83.1	11	94.5	13.6	98
3.3	15.8	5.9	37	8.5	84	11.1	94.7	13.7	98.1
3.4	16.6	6	38	8.6	84.8	11.2	94.9	13.8	98.2
3.5	17.3	6.1	39.1	8.7	85.3	11.3	95.1	13.9	98.3
3.6	18	6.2	40.2	8.8	86.1	11.4	95.3	14	98.3
3.7	18.8	6.3	41.3	8.9	86.7	11.5	95.4	14.1	98.4
3.8	19.5	6.4	42.5	9	87.2	11.6	95.6	14.2	98.5
3.9	120.3	6.5	43.9	9.1	87.8	11.7	95.8	14.3	98.6
4	21	6.6	45,2	9.2	88.3	11.8	96	14.4	98.7
4.1	21.8	6.7	46.7	9.3	88.8	11.9	96.2	14.5	98.8
4.2	22.5	6.8	48	9.4	89.3	12	96.3	14.6	98/9
4.3	23.2	6.9	49.5	9.5	89.8	12.1	96.4	14.7	99
4.4	24	7	51	9.6	90.2	12.2	96.5	14.8	99.1
4.5	24.8	7.1	52.9	9.7	90.7	12.3	96.6	14.9	99.1
4.6	25.6	7.2	55.5	9.8	91.1	12.4	96.7	15	99.2
4.7	26.4	7.3	57.8	9.9	91.4	12.5	96.8	15.1	99.3
4.8	27.2	7.4	61	10	91.8	12.6	96.9	15.2	99.4
4.9	28	7.5	65	10.1	92.1	12.7	97	15.3	99.4
5	28.9	7.6	68	10.2	92.3	12.8	97.1	15.4	99.5
5.1	29.7	7.7	71.8	10.3	92.6	12.9	97.2	15.5	99.6
5.2	30.5	7.8	75	10.4	92.9	13	97.3	15.6	99.6
5.3	31.3	7.9	77	10.5	93.2	13.1	97.4	15.7	99.7
5.4	33	8	80.2	10.6	93.7	13.2	97.6	15.8	99.9
5.5	29.5	8.1	73.5	10.7	91.3	13.3	95.9	15.9	98.3
								16	100

Table 4: *Overall maturity scores for girls as reported by Demirjian et al.*[4]

	A	B	C	D	E	F	G	H
31	0.00	0.00	1.68	1.49	1.50	1.86	2.07	2.19
32	0.00	0.00	0.55	0.63	0.74	1.08	1.32	1.64
33	0.00	0.00	0.00	0.04	0.31	0.47	1.09	1.90
34	0.15	0.56	0.75	1.11	1.48	2.03	2.43	2.83
35	0.08	0.05	0.12	0.27	0.33	0.45	0.40	1.15
36	0.00	0.00	0.00	0.69	1.14	1.60	1.95	2.15
37	0.18	0.48	0.71	0.80	1.31	2.00	2.48	4.17

Table 5: *Individual maturity scores for boys expressed directly in years for each of the developmental stages.*[10]

	A	B	C	D	E	F	G	H
31	0.00	0.00	1.83	2.19	2.34	2.82	3.19	3.14
32	0.00	0.00	0.00	0.29	0.32	0.49	0.79	0.7
33	0.00	0.00	0.6	0.54	0.62	1.08	1.72	2
34	-0.95	-0.15	0.16	0.41	0.6	1.27	1.58	2.19
35	-0.19	0.01	0.27	0.17	0.35	0.35	0.55	1.51
36	0.00	0.00	0.00	0.62	0.9	1.56	1.82	2.21
37	0.14	0.11	0.21	0.32	0.66	1.28	2.09	4.04

Table 6: *Individual maturity scores for girls expressed directly in years for each of the developmental stages.*[10]

	<9mm			<9mm			>9mm		>9mm	
Tooth	Intact Roots			Tooth Sections			Intact Roots		Tooth Sections	
	B0	B1	B2	B0	B1	B2	B0	B1	B0	B1
11	20.30	5.74	0.000	21.02	6.03	-0.060	20.34	5.74	22.36	5.39
21	24.30	6.22	-0.119	26.84	6.00	-0.155	26.78	4.96	30.18	4.30
12	18.80	7.10	-0.164	23.09	7.04	-0.197	22.06	5.36	25.55	5.23
22	20.90	6.85	-0.223	24.62	5.18	-0.077	25.57	4.38	25.90	4.39
13	26.20	4.64	-0.044	21.52	6.49	-0.171	28.13	4.01	28.01	4.23
23	25.27	4.58	-0.073	24.64	5.22	-0.143	27.59	3.65	29.41	3.32
14/24	23.91	3.02	0.203	29.98	2.73	0.107	18.42	5.40	28.44	3.81
15	23.78	5.06	-0.064	24.76	4.81	0.000	25.33	4.28	24.75	4.81
25	25.95	4.07	-0.067	22.34	7.59	-0.393	26.92	3.37	26.21	4.03
41	9.80	12.61	-0.711	13.63	12.11	-0.683	29.00	4.23	31.78	4.19
31	23.16	9.32	-0.539	26.46	8.79	-0.511	37.56	2.94	37.89	3.08
42	26.57	7.81	-0.383	21.77	10.19	-0.581	38.81	2.81	38.49	3.03
32	18.58	10.25	-0.538	22.22	9.07	-0.444	33.65	3.53	35.19	3.49
43	23.30	8.45	-0.348	24.34	8.38	-0.358	37.80	3.50	40.32	3.05
33	27.45	7.38	-0.289	23.88	8.76	-0.388	41.50	2.84	42.07	2.73
44	24.83	6.85	-0.237	21.54	8.63	-0.395	30.83	4.05	33.10	3.66
34	29.17	5.96	-0.173	26.02	7.00	-0.234	34.97	3.74	32.79	4.11
45	29.42	4.49	-0.065	14.90	9.93	-0.451	30.68	3.76	27.46	4.17
35	18.72	5.79	-0.082	23.87	5.50	-0.098	20.87	4.79	25.60	4.41
16/26mr	30.25	3.23	-0.018	28.22	4.82	-0.101	30.56	3.00	30.03	3.48
36/46mr	27.39	6.25	-0.239	33.42	5.18	-0.302	30.32	3.66	35.27	2.78
16/26dr	34.73	0.67	0.211	20.43	6.09	-0.182	29.49	3.32	26.89	3.55
36/46dr	30.21	5.52	-0.181	29.91	4.97	-0.102	31.46	3.77	30.31	4.22
16/26pr	27.43	3.64	0.039	25.15	4.34	-0.032	26.81	4.07	25.83	3.95

Table 7: *Regression constant and the regression coefficients as reported by Bang and Ramm[16]. Differentiation was made on the level of substrate (intact or sectioned teeth) and length of the translucent zone (<9 mm and >9 mm). (m = mesial; d = distal; p = palatal; r = root)*

#	COLOUR AND GENDER INCLUDED
MAXILLARY	
1	AGE = 24.3 + 8.7CEST + 5.2TD - 2.3CAP - 4.3SEX
2	AGE = 38.7 - 126ST + 4.7CEST + 4.2TD + 0.05C1
3	AGE = 10.1 + 2.3TID + 4.4SJ + 6.1CEST
4	AGE = 8.0 + 7.3CEST + 4.1 SJ + 1.4TID
5	AGE = 6.1 + 9.1CEST + 3.3AJ + 7.3 LPMEAN + 1.4TID
MANDIBULAR	
1	AGE = - 21.8 - 55.3SC + 32.8LC1 - 10.3SEX + 2.6TID
2	AGE = - 24.5 + 4.9CEST + 2.1TID - 7.0SEX +20.1LC1 + 2.4AJ
3	AGE = 19.2 + 1.7TID + 5.1CEST + 3.5SJ
4	AGE = - 28.1 + 3.0TID + 0.6ARA + 24.1LC1 - 5.6SEX + 7.3LPMPEAN
5	AGE = 7.5 + 2.7TID + 4.9SJ + 4.9SRS
#	**COLOUR AND GENDER EXCLUDED**
MAXILLARY	
1	AGE = 25.3 + 7.1TID - 3.1CAP + 5.3SRS - 7.5EX3 + 0.02C1
2	AGE = 46.7 - 142ST + 6.5TD + 0.05C1
3	AGE = 12.1 + 2.9TID + 4.9SJ + 3.9SRS
4	AGE = 14.6 + 6.3SJ + 2.5TID
5	AGE = 14.2 + 2.5TID + 4.1AJ + 8.9LPMEAN + 3.0SJ
MANDIBULAR	
1	AGE = -32.1 - 52.5SC + 31.1LC1 + 1.9TID + 4.6SRS
2	AGE = 37.1 + 2.7TID + 5.9SRS - 46.3SC
3	AGE = 27.5 + 2.6TID + 4.4SJ
4	AGE = -26.9 + 3.2TID + 0.5ARA + 22.3LC1 + 7.1LPMEAN
5	AGE = 7.5 + 2.7TID + 4.9SJ + 4.9SRS

***Table 8:** Multiple regression formulae with age as the dependent variable. For each tooth type, parameters that were strongly correlated with age were used in the regression formulae. Explanations for the abbreviations used may be found in the overview above.*[17]

TEETH	EQUATION	r^2
11/21 12/22 15/25		
32/42 33/43 34/44	AGE = 129.8 - 316.4(M) - 66.8(W-L)	0.76
11/21 12/22 15/25	AGE = 120.0 - 256.6(M) - 45.3(W-L)	0.74
		0.71
32/42 33/43 34/44	AGE = 135.3 - 356.8(M) - 82.5(W-L)	
11/21	AGE = 110.2 - 201.4(M) - 31.3(W-L)	0.70
12/22	AGE = 103.5 - 216.6(M) - 46.6(W-L)	0.67
15/25	AGE = 125.3 - 288.5(M) - 46.3(W-L)	0.60
32/42	AGE = 106.6 - 251.7(M) - 61.2(W-L) - 6.0(G)	0.57
33/43	AGE = 158.8 - 255.7(M)	0.56
34/44	AGE = 133.0 - 318.3(M) - 65.0(W-L)	0.64

***Table 9:** Multiple regression formulae for dental age estimation based on radiological measurements.*[18]

TOOTH		EQUATION
11/21		AGE = 71.2 - 133.7FWM - 56.0 FWC
12/22		AGE = 69.3 - 14.5FWM - 63.0FWC
13/23		AGE = 120.2 - 62.5FL
14/24		AGE = 82.0 - 95.9FWC + 2.0T + 1.7P - 50.6FL
	*	AGE = 112.6 - 85.0FWC + 2.4P - 116.3FWM - 64.8FL
15/25		AGE = 30.8 + 2.5P -96.0FWC + 3.7T
	*	AGE = 36.9 + 2.9P - 102.9FWC
31/41		AGE = 40.3 - 122.4FWC + 4.4T
	*	AGE = 68.5 - 124.4FWC
32/42		AGE = 72.1 - 173.6FWC
33/43		AGE = 43.8 - 139.6FWC + 3.8T
	*	AGE = 75.9 - 174.7FWC
34/44		AGE = 75.5 - 185.9FWC - 105.4FWM + 1.4P
35/45		AGE = 54.0 - 107.0FWM - 97.0FWC + 2.4T
	*	AGE = 80.0 - 192.7FWM - 96.6FWC

* excluding apical translucency

Table 10: *Multiple regression formulae for dental age estimation based on radiological measurements.* [19]

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