AGE ESTIMATION OF UNIDENTIFIED CORPSES BY MEASUREMENT OF ROOT TRANSLUCENCY

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ABSTRACT

To evaluate the root dentine translucency technique for age analysis, age estimates carried out at the Institute of Legal Medicine at the Charité University Hospital in Berlin between 1998 and 2002 of unidentified corpses were subjected to retrospective review. Teeth suitable for evaluation were obtained from 33 corpses of undisputed identity. Root translucency was measured at intervals of half a millimetre. Appropriate reference studies were used to translate the measurements obtained into estimated age. In 18 cases these estimates proved correct. In 14 cases the deviation lay within +/-10 years. In one case of known drug abuse combined with diabetic metabolism, two factors which promote the advance of root translucency, the deviation was 12 years.

It was concluded that the described technique, which requires little time and money and is easy to apply, can produce sound results in the middle age group (30–60). To avoid seriously inaccurate estimates in individual cases, the result should always be verified critically against an assessment of the overall stomatognathic system and other post-mortem findings of relevance to age.

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INTRODUCTION

Estimating age with maximum precision is helpful when identifying unknown corpses by defining, in conjunction with missing persons or passengers lists, possible candidates.

While teeth are still developing assessment of eruption status or mineralization stages permits relatively accurate diagnosis of a person's age, whereas in later years estimates display a greater range. The first scientific method to be devised for use in adults was described by Gustafson,[1] who listed six parameters (abrasion, periodontal status, secondary dentine formation, cement apposition, root resorption and root translucency) for observations in tooth sections. Gustafon's method was modified by Dalitz[2] and Johanson[3], who amended both the parameters themselves and the way they are weighted.

After extensive testing, Bang and Ramm[4] concluded that measuring root translucency was by itself a simple and acceptable method for estimating age. They were, furthermore, the first to indicate that it was possible to obtain the same quality of results from using intact teeth as from using tooth sections

Wegener and Albrecht[5] provided corroboration for the method devised by Bang and Ramm[4] to measure root translucency, with best results obtained with subjects aged 30-60 years. Kuhl[6] examined the performance of the root translucency technique in estimating age and observed an accuracy of +/- 10 years in 85% of cases while the deviations produced in the remainder of samples were sometimes considerable. Hennig[7] considered the feasibility of determining the age of individual teeth using root translucency with a population drawn from the 10th to 12th century. The author devoted detailed attention to changes in teeth after death and investigated processes triggered by biological parasites and chemical conversion. Hennig refers to a study conducted by Wedl in 1870 which showed that when tooth sections were preserved in a liquid with fungal spores the previously transparent dentine grew clouded after 31 days at the latest. Hennig also argues that certain chemical conversion processes can encourage inaccurate age estimates when using root translucency. Depending on soil conditions, the highly insoluble hydroxyapatite found in dentine may be transformed into more readily soluble brushite, but remineralisation is equally possible.

Drusini *et al*.[8] discovered a strong correlation in their research between root translucency and chronological age. They were also able to show that unsectioned teeth display a closer correlation with age than histologically prepared teeth, that canines are difficult to assess because they have more voluminous roots, and that there are no gender-specific differences in the advance of root translucency.
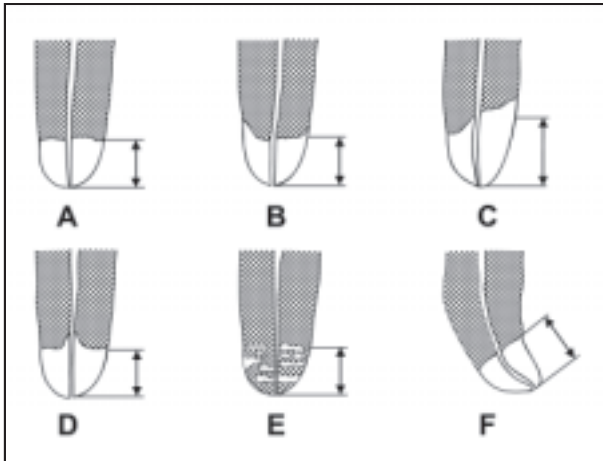
Fig.1: *Measuring criteria for root translucency based on Scharf.*[11]

Fig.2: *Dental transilluminator*

Landrock[9] was able to demonstrate that root translucency can be determined for molars, and that due to their anatomy maxillary molars lend themselves more easily than mandibular molars to translucency measurement by means of a transilluminator.

Anyone using the root translucency technique in practice confronts the problem that the existing reference studies show pronounced differences with regard to their interpretation of age and that in some cases the age spectra display a wide scatter.

However, age estimation with a dispersion of more than ten years is hardly any use to investigators seeking to narrow down the identity of a deceased person within a potential group.

When forensic odontologists at the Institute of Legal Medicine at the Charité estimated the age of unknown corpses by means of the root translucency method they resorted to a process whereby the mean values of various different reference studies[4,6,10] were combined into a single age interval, leaving aside the standard deviations described by the various authors. The product was stated in the report as the probable age of the corpse. The present paper subjects this process to critical review, taking as its material corpses assessed between 1998 and 2002 whose identity had meanwhile been established beyond doubt. At the same time, it considers how tenable root translucency is as an age-defining characteristic.

MATERIALS AND METHODS
During the period under review (01/01/1998-30/09/2002) the Institute of Legal Medicine at the Charité carried out age estimates by measuring root translucency on 39 unidentified corpses submitted for post mortem. In 35 cases the corpses were then identified beyond doubt while in two of these cases it was not possible to measure root translucency.

Thirty three cases were, therefore, available for assessment, consisting of 26 men and 7 women aged 19-71. Thirty of the corpses examined were classified ethnically as Caucasoid, and three as Mongoloid.

One or two mandibular incisor teeth were extracted, cleaned and the length of the transparent root dentine measured in 1/2mm steps (Fig.1). The measurements were performed using a dental transilluminator (Medico-technical laboratories, Charité Berlin, Germany) (Fig.2) as described in the technique by Ziller.[12] All teeth were assessed by the same researcher, who was not acquainted with the personal data of the corpses concerned.

The measurements, accurate to 1/2mm were used to determine an estimated age or age range based on the mean values for the tooth in question given in the studies of Bang and Ramm,[4] Kuhl[6] and Wonneberg[10] (Table 1). The age range was created from the smallest and largest mean value, with the standard deviations provided by the authors disregarded.

Table 1: Mean ages in years and related root translucency as reported by Bang and Ramn,[4] Kuhl[6] and Wonneberg.[10]

RT [mm]	Bang & Ramm				Kuhl	Wonneberg
	Tooth 31	Tooth 41	Tooth 32	Tooth 42	Teeth 33-43 (mean)	Teeth 33-43 (mean)
0.5	39	31	35	40	25	22
1.0	41	33	37	42	28	26
1.5	42	35	39	43	31	30
2.0	43	37	41	44	35	34
2.5	45	40	42	46	38	38
3.0	46	42	44	47	42	42
3.5	48	44	46	49	45	46
4.0	49	46	48	50	49	50
4.5	51	48	50	51	52	55
5.0	52	50	40	53	56	59
5.5	54	52	53	54	59	63
6.0	55	54	55	56	62	67
6.5	57	56	57	57	66	71
7.0	58	59	58	58	69	75
7.5	60	61	60	60	73	79
8.0	61	63	62	61	76	83
8.5	63	65	64	63	-	-
9.0	64	67	65	64	-	-
9.5	65	69	67	66	-	-
10.0	67	71	69	67	-	-

The following method was used to determine the difference between actual age and estimated age or age range: if the actual age lay within the estimated age range or the estimated age tallied with the actual age, the estimation was rated as correct. Deviation was determined in each case as the difference between actual age and the upper or lower margin of the interval of estimation.

The post-mortem reports were scrutinized for any indication of metabolic disorder or drug abuse, as root translucency can be assumed to be more pronounced under such circumstances.

RESULTS
Table 2 lists the gender and ethnic origin of subjects along with the measurements obtained from suitable teeth, the resulting age diagnosis and the deviation between estimated and actual age.

The estimate was correct on 18 occasions, 14 cases fell within a deviation of +/-10 years and in one case the deviation was 12 years. Fig.3 shows the age distribution for the difference between actual and estimated age of the subjects under review.

Table 2: Subject data, measurements by tooth and accuracy of estimates

No.	Gender	Ethnic origin	Tooth	Measurement [mm]	Estimated age [years]	Actual Age [years]	Deviation [years]
1	male	caucasoid	31	5.0	52-56	54	0
2	female	caucasoid	31	1.0	26-41	29	0
3	male	caucasoid	41	3.0	42-46	33	-9
4	male	mongoloid	12	5.0	52-59	57	0
5	female	mongoloid	41	1.0	26-33	24	-2
6	male	caucasoid	41	2.5	38-40	42	+2
7	male	caucasoid	41	1.0	26-33	19	+7
8	male	caucasoid	41	3.5	44-47	41	-3
9	female	caucasoid	41	3.0	42-46	44	0
10	male	caucasoid	31, 41	6.0	54-67	54	0
11	male	caucasoid	41	1.5	30-35	30	0
12	male	caucasoid	42	6.5	57-71	69	0
13	male	mongoloid	41	2.0	34-37	37	0
14	male	caucasoid	41	2.0	34-37	32	-2
15	male	caucasoid	41, 32	5.0	46-52	34	-12
16	male	caucasoid	42	3.5	45-49	45	0
17	female	caucasoid	42	4.0	49-50	54	+4
18	female	caucasoid	42, 31	<0.5	<31	20	0
19	male	caucasoid	42	3.0	40-47	40	0
20	male	caucasoid	32	3.0	42-44	47	+3
21	male	caucasoid	42	1.5	30-43	23	-7
22	male	caucasoid	32	0.5	22-30	24	0
23	male	caucasoid	32	6.0	54-67	60	0
24	male	caucasoid	41, 42	5.0	50-59	60	+1
25	female	caucasoid	41, 42	1.0	26-42	34	0
26	male	caucasoid	32	6.0	54-67	56	0
27	male	caucasoid	41, 42	4.0	44-50	56	+6
28	male	caucasoid	42	2.5	38-46	39	0
29	male	caucasoid	41	2.5	38-40	35	-3
30	male	caucasoid	42	6.0	56-67	71	+4
31	male	caucasoid	41	1.5	30-35	31	0
32	female	caucasoid	42	7.0	58-75	63	0
33	male	caucasoid	41	6.0	54-63	65	+2

In eight cases the subjects were estimated to be younger than they were; seven of these subjects were over 40, one was between 10 and 19 years-old. In seven cases the subjects were estimated to be older than their true age; of these six were aged between 20 and 39 yrs, and one was between 40 and 49 yrs.

Five of the seven women were correctly assessed. One woman was assessed two years too old and one woman four years too young. Of the three Mongoloid subjects one was correctly assessed, whereas for the other two the estimated age was two years above their true age.

Evaluating post-mortem reports on the persons under review revealed in one case that there had been drug abuse (methadone) combined with diabetic metabolism, and in this instance the age of the subject had been overestimated by 12 years.
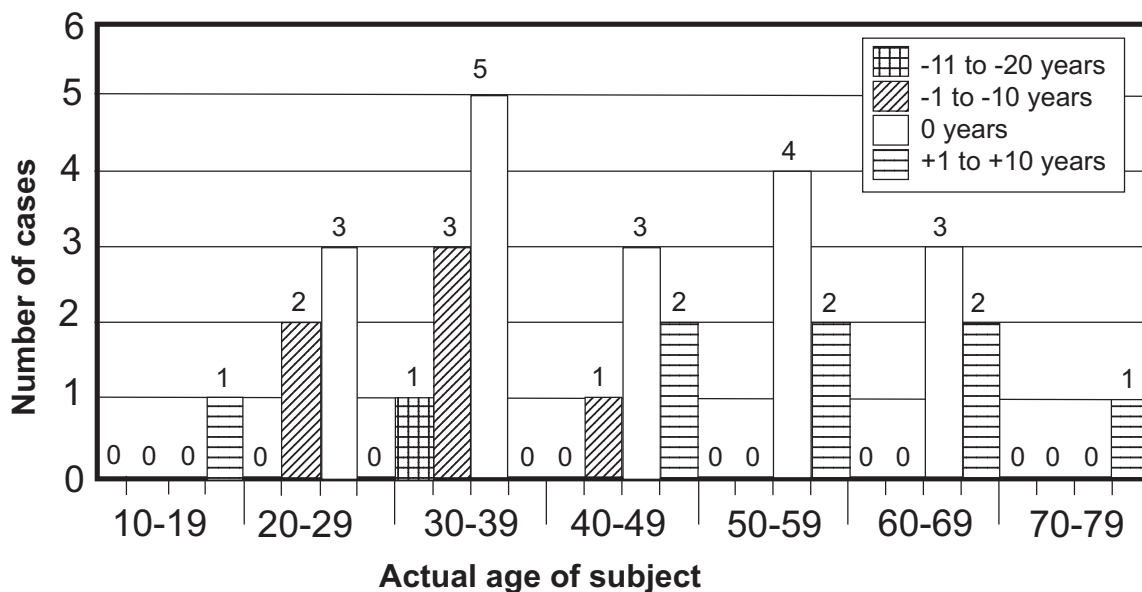
Fig.3: *Age distribution for the differences between actual and estimated ages of subjects. Negative difference mean: estimated age > actual age. Positive difference means: estimated age < actual age*

DISCUSSION

According to Simon and Armstrong[13] it was Miller 1903 who coined the term "dentine translucency". Dentine constitutes the bulk of a tooth and is composed of water (13.2%), organic matter (17.5%) and inorganic matter, i.e. Ca, P, Mg and other substances, (63.3%). Ageing dentine is characterised by depletion of water, changes in the organic substances and a gradual formation of mineral deposits. Permanent mineralisation due to odontoblasts occludes the lumina of dentine tubules. This mineralisation begins in the narrowest tubules at the apex and in the periphery of the root.[14] The translucency phenomenon itself is the result of calcium salts clogging the spaces between tubules, so that the refraction index of this intratubular material is increasingly similar to that of the original extratubular substance.[15,16] The depositing of mineral salts, combined with tubular obliteration and water depletion, is known as dentine sclerosis.

Pilz[16] concluded that the age-induced phenomenon of translucency in healthy root dentine must reflect the metabolic and ageing processes occurring in the marrow itself. Degeneration within the pulp is more pronounced around the apex than around the crown. Cellular atrophy is expressed in a decline in the number of odontoblasts. Changes brought about by atrophy display marked spatial differences between the coronal and root pulp, and this is at least one explanation for increasing translucency from the apex towards the crown.

Given the need for rapid age estimation during post-mortem examination, the present study was designed to review the usefulness of measuring root translucency. As there are some substantial deviations in the age data provided by reference studies, we determined estimated age as the age range between the largest and smallest mean culled from the reference data, leaving aside the standard deviations defined by their authors. This technique led to some wide age ranges, especially for younger age groups. The substantial differences between reference study mean values for younger subjects are no doubt associated with the difficulty of measuring incipient root translucency in half millimetres.

The error rate observed in our work is similar in magnitude to the figures given by Wegener and Albrecht[5] and by Kuhl.[6] This indicates that our chosen method was a practicable one but the relatively small size of our sample should be noted.

Olze *et al*.[17] recently published a study which uses exactly the same method to investigate the macerated jaws of 55 corpses at the Forensic Institute of Zurich University. In 54 cases teeth were available for evaluation. The estimates proved correct in 18 instances, 44 estimates fell within a 10-year deviation, another seven within a deviation of 15 years, two more within a deviation of 20 years and in one case the deviation was 30 years.

The greater deviations compared with the Berlin study might be explained by changes in root translucency incurred as a result of maceration and the adhesion of teeth to the jaws preserved at Zurich. In addition, the results of measurement can be influenced by the subjective overall impression which the researcher gains of the corpse, especially when the border of translucency is not clear-cut. As Solheim and Sundnes[18] have shown, subjective estimates of age by an experienced forensic dentist are no less precise than estimates of age founded on scientific techniques such as those of Bang and Ramm,[4] Miles,[19] Johanson[3] and Dalitz.[2]

Our results have confirmed the tendency described by Wegener and Albrecht[5] and Kvaal *et al*.[20] for younger ages to be overestimated and older ages to be underestimated. Apart from the problems of measurement in the case of young corpses as described above, the processes which influence the extent of root translucency evidently slow down with age.

An additional source of error in measurements is associated with the fact that in practice the border of translucency is often blurred. In many instances no acceptable measurements can be taken at all, and in these cases extractions must continue until a tooth proves suitable for evaluation.

Neither this study nor the Zurich findings[17] gave any cause to suspect that gender or ethnic origin might substantially influence estimates.

Ziller[12] demonstrated that root translucency cannot be used to estimate age when there are clear macroscopic or biochemical indications of previous drug abuse in an unidentified corpse, as the development of root translucency would be accelerated and reinforced by the earlier triggering and substantially greater advance of pulp and dentine ageing. Similarly, diabetic metabolism can be expected to promote the development of root translucency.[6,21]

In this study there was evidence in one case that the subject had experienced both drug abuse and diabetic metabolism, and this provides an explanation for the only deviation between actual and estimated age to exceed the 10-year deviation.

CONCLUSION

The present research permits the conclusion that measurement of root translucency is a feasible technique for age estimation based on the procedure we have described and that good results can be expected in the middle age group (30–60 years). Greater deviations are possible in the younger and older age groups, with a tendency to overestimate the age of younger persons and to underestimate the age of older persons.

The method lends itself to initial age estimation of unidentified corpses both during ordinary post-mortem examination and in the event of a mass disaster. Advantages include a low input of time and financial resources and easy application.

Nevertheless, anyone using the method should remain constantly aware that substantial errors may occur in individual cases. The examiner should therefore always verify the result of the estimate against a visual assessment of ageing characteristics in the overall stomatognathic system; an experienced forensic dentist will probably produce a fairly accurate estimate.

Moreover, the age diagnosis based on measuring root translucency should be checked against the age estimate of the forensic pathologist based on external physical features and the condition of internal organs. Information should be requested about possible drug abuse or any discovery of a metabolic disorder, and this should be taken into account where necessary. If serious discrepancies emerge between the age estimate based on measuring root translucency and other findings, a recommendation should be made to the investigating authority to apply one of the more complex and expensive techniques for estimating age, such as determining the racemisation of aspartic acid in dentine or cement annulation.

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