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CASE REPORT

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The Use of Dental Aging Techniques in Forensic Odontological Practice

ABSTRACT: Many studies have been published describing numerous techniques to determine the aging of individuals from dental tissues. However, few case reports demonstrate how such techniques can be employed by the forensic odontologist undertaking casework. Indeed, many of the techniques are highly complex and utilize equipment not generally available to odontologists outside of the university or hospital systems. This paper describes five cases where dental aging was used for identification in the absence of materials for any other techniques. In each case the Bang and Ramm method was employed using sectioned teeth. Teeth were sectioned, photographed, and scaled in image analysis software. Bang and Ramm equations were employed, and in each case an age was derived. The estimated age was supplied to the coroner, who was able to use the information to positively identify five individuals for whom no other identification system was feasible.

KEYWORDS: forensic science, forensic odontology, aging, dentine, translucency, case report

For over a century it has been known that the age of adult (>21 years) individuals can be determined from changes within the hard tissues of their teeth (1–4). Numerous techniques exist, and a number of excellent reviews have been written, with a recent article providing a consensus view on which techniques are most appropriate (5–7). Indeed, a number of articles within this journal have recently considered the reliability of the techniques currently employed (8,9). It is beyond the scope of this article to re-review these articles, and the interested reader is referred to the recent literature (10).

Lacking in the literature are actual examples of the techniques in use employing forensic material within authentic casework situations that the forensic odontologist is likely to experience (11). Many of the techniques appear esoteric, particularly those involving biochemical methodologies, and several are extremely costly both in terms of consumables and initial equipment (8). Perhaps the lack of case report data from such techniques is a reflection of the reluctance of odontologists to adopt them. It is the purpose of this case report to demonstrate the use of one of the simpler aging techniques (Bang and Ramm) using simple equipment in five actual cases, two of which are described in detail (12).

Bang and Ramm Technique

Briefly, this technique is based upon the phenomenon of translucent dentine development within the root of the tooth (12). It is well accepted that the amount of translucent dentine increases with age, with an expansion of translucency from the apical portion of the tooth to the coronal (2). The Bang and Ramm (BR) system is used with extracted teeth that can either be assessed for translucency whole or sectioned (7). In the author's experience, it is extremely difficult to assess translucency of unsectioned teeth, and a number of studies have shown that the error rate of aging using whole teeth is less accurate than that of sectioned teeth. This is thought to be due to the variability in cementum coverage and other factors that impact upon the visualization of translucency in intact teeth. Indeed, within Bang and Ramm's original article, the standard errors of aging experiments conducted with whole teeth are significantly higher than with sectioned samples (12). A recent study has shown that the BR technique, while one of the simplest, also carries the smallest error rate, and therefore its use within forensic casework is justified (8).

Equipment

All of the equipment required to employ the BR technique is likely to be had by most forensic odontologists or is inexpensive to purchase. This author uses the following:

1. Diamond wire saw (Walter-Ebner, Switzerland).
   (A Dremmel hand tool is an inexpensive and effective alternate.)
2. Graph paper with 1-mm squares (Viking Stationary Supplies, Leeds, UK).
3. Sony Cybershot 85 Digital Camera (Sony, London, UK).
   [Any high resolution (>3 megapixels) digital camera or conventional 35 mm SLR is acceptable.]
4. Adobe Photoshop (Adobe Inc, CA)
   (Any similar image analysis software with measurement tools will suffice.)
5. A copy of the Bang and Ramm article.

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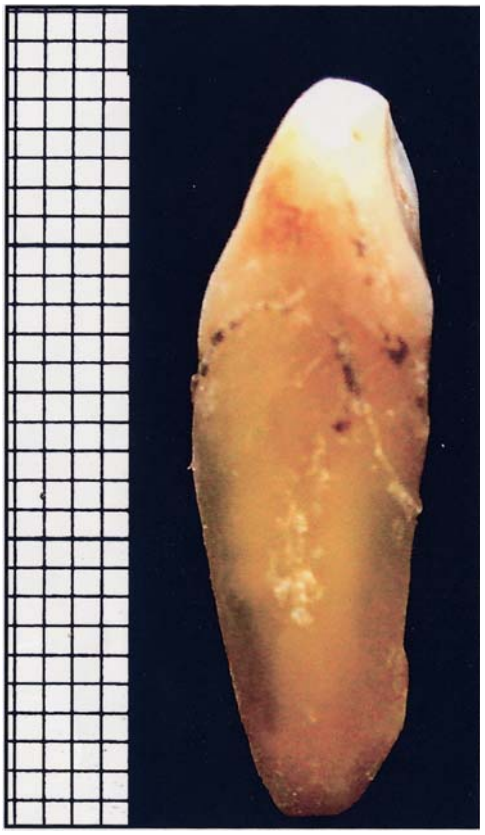

FIG. 1—*Example of a cleaned, unsectioned tooth, photographed against a high-contrast background with an adjacent scale.*

Method

As the technique is destructive (teeth are sectioned), it is important to keep an accurate photographic record of each stage of the procedure. Following a request for a dental aging, and having obtained permission from the responsible agency, teeth should be removed from the deceased individual for processing. As a general rule, as many teeth as possible should be extracted, as this will enable the most reliable aging result. However, permission may be given only for a small number of teeth or teeth may be damaged or missing. If tooth selection is limited, the best aging information is obtained from unrestored maxillary anterior teeth. Photographs should be taken of the teeth *in situ* prior to extraction. Extraction should be conducted using an atraumatic technique to ensure that no fractures or other damage occurs. Teeth should also be radiographed prior to extraction, particularly if they contain restorations (11).

Each tooth should be placed in a sterile universal container (50 mL) labeled with a case and tooth identifier. For cross-infection control the author recommends that distilled water with a few crystals of Thymol is placed in the universal containers. This method has been shown to remove almost all infectious threats from stored hard tissues (13,14).

Following transport of the teeth from the mortuary, each tooth should be removed, dried, and cleaned. Gently remove soft tissue remnants using a periodontal hoe, perform gentle abrasion with wet and dry paper, and finally clean with pumice and a toothbrush. A photograph should then be taken of the tooth against a black background on graph paper, with 1-mm increments. Both the mesial and distal aspects of the tooth should be recorded (see Fig. 1). This process serves two purposes: first it records, in detail, what has been done to each tooth should this information be later requested in court, and, secondly, should you wish to conduct a whole-tooth analysis of translucency this will be possible. The author used digital photography for convenience, as this is easily imported into the image analysis software; however, conventional photography can be employed.

Subsequent to the photography, the tooth should be sectioned along its long axis into mesial and distal sections. Depending on the size of the tooth, more than two sections could be produced, although the author has found that attempting this can result in overly thin sections that can prove difficult to assess for translucency. The cases described here have produced satisfactory results with only two sections resulting from a single slice through each tooth (see Fig. 2). In order to section the teeth accurately, they should be mounted onto a small wooden block and secured with sticky (or green stick) wax to ensure that no movement occurs during the cutting process. A diamond wire saw or Dremmel tool with a small cutting disc attached should be used for sectioning to ensure that only a small amount of material is lost during the cutting process.

Some authors have suggested that the cut sections should be polished prior to analysis, although this has been shown to have no significant effect on the accuracy of measurements and, due to possible damage caused by the polishing process, should be avoided. The sections of each tooth should now be photographed (see Fig. 2).

Measurement of the Translucent Dentine

Each of the images should now be scaled to life-size (1:1) within Photoshop. The measuring tool should be used to measure the length of the translucent dentine from the apex to the most coronal extent (12). Translucency is frequently not even in its distribution, and therefore it is recommended to take two measurements, T_1 and T_2, from each tooth section (see Fig. 3). A mean translucency length, in millimeters, T_M, should be recorded combining both of the measurements obtained, i.e.,

FIG. 2—*Example of a tooth following sectioning, demonstrating both mesial and distal portions. Note that the high contrast background and sectioning permits the translucency to be easily observed. Compare this to Fig. 1.*

$$\frac{(T_1 + T_2)}{2} = T_M$$

Photoshop offers very accurate measurements, greater than those achievable by using conventional techniques. The software also enables the image to be magnified for closer examination and the image can be enhanced by altering the brightness and contrast, facilitating the identification of areas of translucency.

Calculations

The BR technique provides unique equation variables for each tooth both maxillary and mandibular, and in the case of molars each root is assessed individually (12). The published study provides extensive tables containing the appropriate figures to be inserted into the equations, and a number of different formulae are available depending on whether or not the tooth is sectioned or intact. It is a simple matter to insert the mean translucency into the appropriate equation to calculate the estimated age of that tooth with the accompanying error rate. All the data produced should be entered into a spreadsheet and a mean estimated age and standard deviation produced. The equations are provided in easy-to-understand tables within the original publication. This summary should be included in the written report. Increasing the numbers of teeth studied will result in an increased accuracy and smaller standard deviation (12).

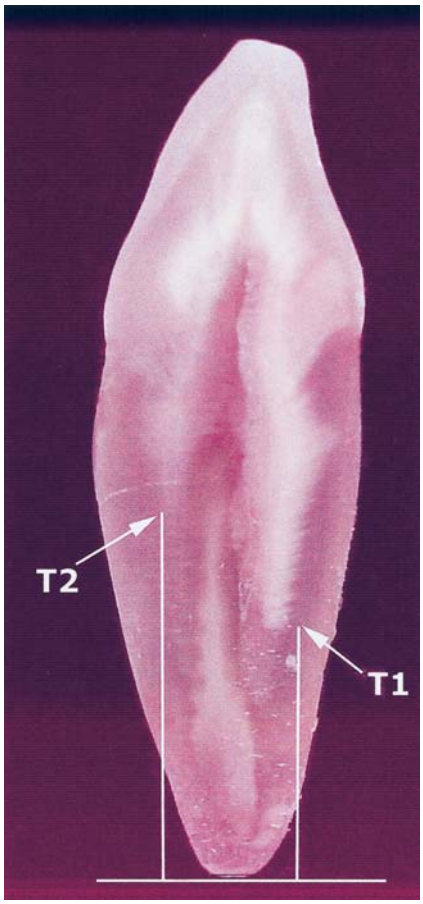

FIG. 3—*Example of the measurement of dentinal translucency. In this example, an uneven degree of translucency is present and therefore two measurements have been taken.*

Case Examples

Case 1

A grossly decomposed male was discovered in a residence in Northwest England following complaints by neighbors of an unpleasant odor. Police noted that the house was locked from the inside and that the deceased was lying, fully dressed, on the bed in the master bedroom. There was no evidence of forced entry or violent act. Neighbors stated that the owner of the house was a recluse, and, although they hadn't seen him for several weeks, this in itself was not unusual. A tentative identification was made based upon the registered owner of the residence. Inquiries were made to obtain dental records, but none could be located; visual identification was impossible due to the degree of decomposition, and no blood relatives were available for a comparative DNA sample. It was decided that dental aging would be conducted. The age of the individual tentatively identified was withheld from the odontologist.

On examination, the individual was edentulous on the maxillary arch, wearing a complete denture with no identification markings. The denture opposed a lower natural arch comprising seven anterior teeth and two heavily restored molars. Permission was given to remove four teeth; these were the lower right canine (LR3) and lateral incisor (LR2) and the lower left canine (LL3) and first premolar (LL4). Each tooth was processed as described previously and analyzed using the equations provided by Bang and Ramm (see Fig. 4, Table 1). From this analysis it was possible to state that the individual examined in the mortuary was 74 years old ($\pm$10 years) at the time of death.

The report was issued to the coroner, who confirmed that the age of the individual who had been tentatively identified was 72 years and 9 months old at the time of death. Therefore, the age range proposed from the analysis of the teeth would have included someone of this age. In the absence of any factors suggesting that the individual in the mortuary was not that of the purported individual, a positive identification was made by the coroner.

Case 2

A body of a decomposed male was discovered in dense undergrowth near a major river in the Merseyside region, England. Near the scene were a number of objects suggesting a suicide. A search of the body revealed a National Insurance card, and this was traced to provide a tentative identification. The purported individual had been homeless for a number of years and had a history of mental illness. A search of the UK's Dental Practice Board records revealed that the individual was not registered to a National Health Service dentist and that his likely financial status suggested that he would not have sought private treatment. A post-mortem dental examination revealed that no recent dental treatment had taken place.

No visual or DNA identification was possible, and therefore the coroner gave permission for a total of five teeth to be removed for the purpose of dental aging. The following teeth were removed: the lower left lateral incisor (LL2), the upper left central incisor (UL1), the upper left canine (UL3), the upper right central incisor (UR1), and the upper right canine (UR3). The teeth were selected based upon lack of restoration and the ease by which they could be extracted. Due to a large degree of attrition (wear), the teeth had unusually short clinical crowns, making tooth fracture during extraction more probable. Indeed, the degree of incisal wear had led to a presumptive age estimate of an elderly individual, over 65 years of age (Fig. 5). Again, the coroner withheld the tentative date of birth from the odontologist.

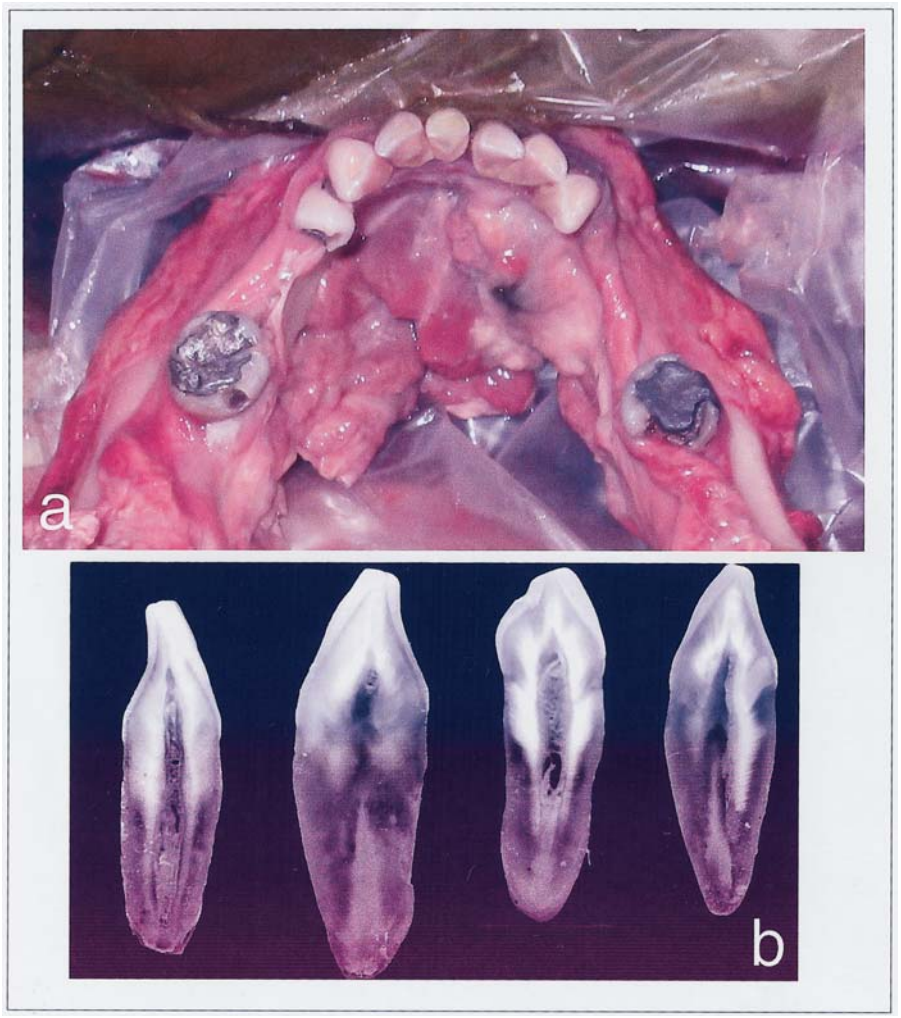

FIG. 4—*Case 1:* (a) *Clinical presentation demonstrating decomposition and the poor state of the remaining dentition;* (b) *sectioned examples of the teeth extracted in this case. Note that by simple observation there is a large degree of translucency, indicating that this is an elderly individual.*

TABLE 1—*Data obtained in Case 1.*

Tooth Section	T_1, mm	T_2, mm	T_M, mm	Estimated Age, years	SD
LR2 Section 1	9	9.4	9.2	66.30	11.26
LR2 Section 2	10.2	9.8	10	68.80	11.26
LR3 Section 1	12	12.2	12.1	77.25	10.74
LR3 Section 2	13.2	12.2	12.7	79.00	10.74
LL3 Section 1	14.8	12.9	13.85	79.00	9.96
LL3 Section 2	15	13.2	14.1	80.20	9.96
LL4 Section 1	9	8.5	9.75	68.75	8.39
LL4 Section 2	10.8	9.9	10.35	75.32	8.39
Mean				74.32	10.08

Each of the extracted teeth was processed as previously described and the data entered into Excel. The age estimates from each of the teeth are shown in Table 2. The estimated age at death for this individual was 49 years (±12 years), which was below that anticipated following an assessment of the tooth wear. The results were reported to the coroner, who confirmed that the age of the purported individual was 51 years 2 months at the time of death. Given the lack of any other discrepancies, and the close alliance between the age estimate and that of the purported individual, a positive identification was made by the coroner.

Cases 3–5

The circumstances surrounding these cases is broadly similar to those described previously, namely that age verification was employed to identify the individual in the absence of any other method. Table 3 shows the results of these cases. In each example a positive identification was made by the coroner based upon the age estimation provided and the lack of any other evidence suggesting that the individual was someone other than that suggested by the original tentative identification. In each of these cases, no other method of identification was possible, and therefore the aging technique proved to be the only objective evidence available to the coroner.

Discussion and Conclusion

The case reports described here demonstrate: (a) that the BR aging technique is simple to implement and, using authentic forensic materials, produces useful results, and (b) that the BR aging technique can help determine the age range of a body otherwise unidentifiable (11). It should be noted that in each of these cases

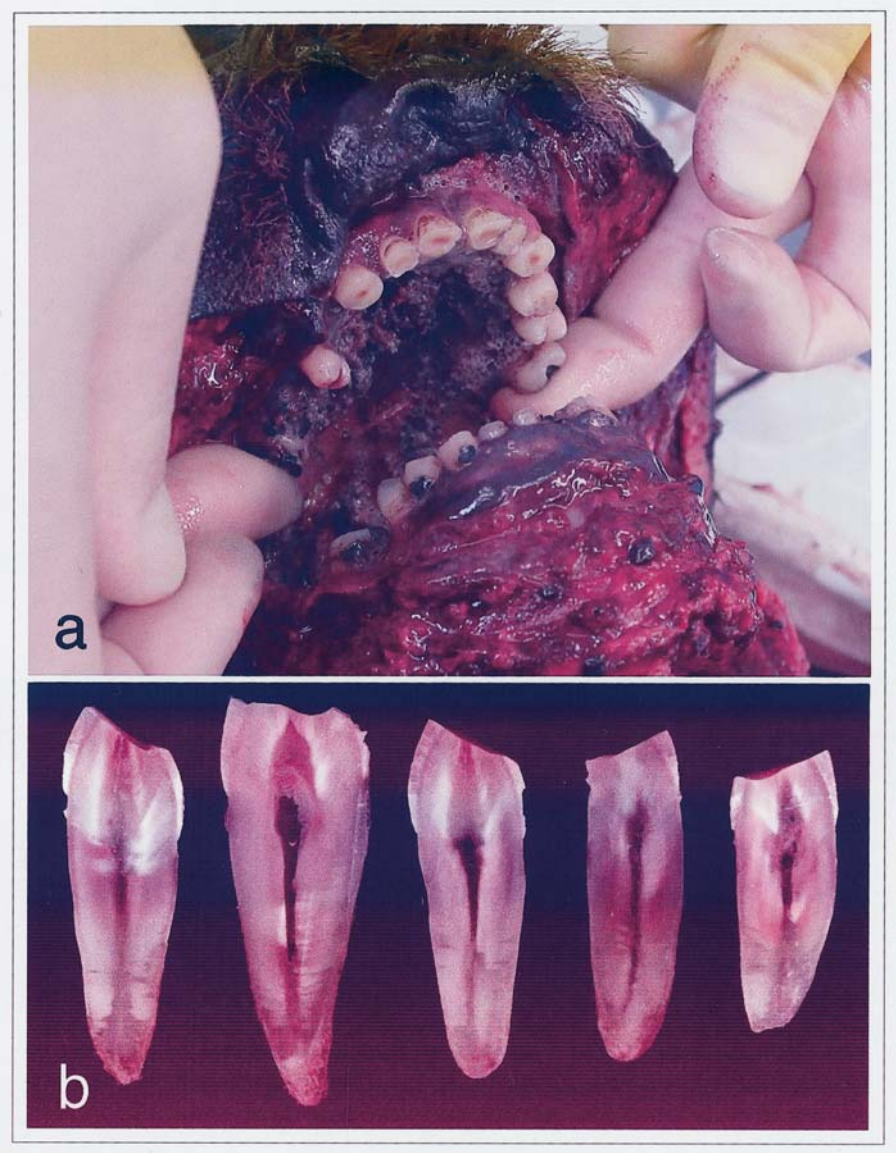

FIG. 5—*Case 2:* (a) *Clinical presentation: note the gross decomposition and extensive incisal wear (with dentinal exposure) visible on the anterior teeth;* (b) *sectioned teeth from this case. Note that despite the extensive wear, only a small amount of translucency is noted, indicating that this is a younger individual. Contrast with Fig. 4.*

TABLE 2—*Data obtained in Case 2.*

Tooth Section	T_1, mm	T_2, mm	T_M, mm	Estimated Age, years	SD
LL2 Section 1	4	7	5.5	58.60	10.78
LL2 Section 2	4.5	6.1	5.3	57.82	10.78
UL1 Section 1	3	3.3	3.15	44.17	11.03
UL1 Section 2	2.5	3.2	2.85	42.69	11.03
UL3 Section 1	5.1	5.3	5.2	48.28	13.78
UL3 Section 2	3.5	4.5	4	43.24	13.78
UR1 Section 1	3.5	6	4.75	48.31	11.43
UR1 Section 2	3	3.2	3.1	44.71	11.43
UR3 Section 1	3.5	4.2	3.85	49.03	13.29
UR3 Section 2	5.2	5	5.1	57.14	13.29
Mean				49.40	12.06

TABLE 3—*Data from Cases 3–5.*

Deceased Details	Estimated Age, years	No. Teeth	Actual Age, years	ID?
Grossly decomposed female	78 (±12)	6	76.3	Yes
Burnt male, road traffic accident*	49 (±11)	4	45.2	Yes
Grossly decomposed male	85 (±9)	7	82.9	Yes

* Victim subsequently identified by dental records following age estimation.

aging was the only method of identification available, although in one case dental records subsequently became available and were used to further strengthen the identification. The case reports are useful in that they confirm the technique described by Bang and Ramm using forensic material. Taphonomic changes have been described in teeth, and most aging literature describes freshly extracted teeth from living individuals (15,16). The data described here are therefore confirmatory in nature.

The time taken to perform dental aging is minimal, depending on the number of teeth, taking 4 h on average. The simple equipment and ease of calculation afforded by the BR technique, allied with the examples provided here, should encourage forensic odontologists to attempt aging determination within their casework requirements.

The BR technique is a reliable forensic tool (8). Forensic odontologists are recommended to undertake practice cases prior to using authentic case materials. Aging data may enable identification of a deceased individual to be made in the absence of materials permitting more traditional methodologies (7). It is important to note that the use of an aging technique cannot, by itself, be used to positively identify an individual. Instead, such techniques represent additional information that can assist the coroner or medical examiner in arriving at their decision. This may be supplemented by the results of other tests, or, as in these cases, the absence of any other information suggesting that the identification was erroneous. None of the cases described in this report were connected to criminal activities, and it was not necessary to defend any of the identifications in court.

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