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Contents

Developments in Cranio-Facial Superimposition for Identification

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Cranio-facial superimposition is a method of comparing the characteristic features of a skull with a photograph of a person whose identity is known. As a technique to aid the personal identification of unknown human remains, it is not new. The principle of identification of skulls by reference to portraits of known persons was used in Germany by Hermann Welcker[1], Professor of Anatomy at the Halle University, during the latter half of the last century and Karl Pearson[2] in 1926-34. These workers made numerous attempts to authenticate reputed skulls of historically famous persons by comparison with their painted portraits, death masks or sculptured busts, or conversely, to determine the true likeness of a portrait by comparison with known skulls. In none of these early studies were photographs used.

Although Furuhata[3] in 1958 claimed to have identified a man's skull by facial restoration and superimposition as early as 1925, probably the most notable occasion when this method was used with considerable success in a criminal case was in the identification of Isabella Ruxton and Mary Jane Rogerson in Scotland in 1935.[4]

In the Ruxton case, considerable thought and effort had been exercised by the murderer in an attempt to prevent identification of his victims. Buck Ruxton, a medical practitioner, had murdered his wife, Isabella Ruxton and her maid, Mary Jane Rogerson. He had then removed eyes, noses, lips and large portions of the skin of the faces and scalps of his victims, as well as numerous teeth from their jaws. Because of the limited material available for identification, the investigators decided to attempt to compare the skulls of the victims with portrait photographs of the missing persons, superimposing photographs of the skull over the portraits.

Superimposition has subsequently become an important and frequently used addition to the armamentarium of methods available for the identification of skeletal remains.[5]

An unusual case from Yugoslavia was undertaken in 1976 by Palmovic.[6] Confronted by the need for religious purposes to provide positive identification of the skeletal remains of a nun who had been buried in a communal grave, Palmovic carried out a series of superimpositions of 6 skulls recovered from the grave over a photograph of the nun and, by this means, was able to select the correct skull. Lesions found in the spine of the deceased corresponded with known medical history of the nun and provided supportive evidence of the identification. Palmovic has used superimposition many times in recent years to establish identification.

The principle of superimposition has been applied also to the

identification of portions of skull. Chowdhuri and Majumder[7] in 1975 used this technique to compare the upper dental arch of a skull with that appearing on a photograph of a skull to settle a dispute involving an alleged substitution of a skeleton by a forensic expert. More recently, Klonaris & Furue[8] compared by superimposition the pattern of tooth sockets in a fragment of maxilla recovered from an aircrash, with an ante-mortem dental radiograph of a missing air crew member.

Methods of Superimposition

Numerous variations in details of superimposition have been described. In the Ruxton case, the following procedures were used:

1. Life-size photographic enlargements from selected photographic portraits were made. 'Life size' was determined in the case of Isabella Ruxton by calculations based on the dimensions of a tiara she wore in the photograph and in the case of Mary Jane Rogerson, the enlargement was calculated by reference to structures of known dimensions in the immediate background of the photograph.
2. Natural size photographs were taken of the skulls which were orientated in the similar positions to those of the heads in the portraits.
3. The outlines of the skulls and of the faces were traced on transparent overlays and compared by superimposing them on each other to determine the degree of correspondence.
4. Transparent negatives of the portraits and transparent positives of the skulls were made by using X-ray film.
5. The transparent positive of each skull was then superimposed in register over the transparent negative of each appropriate portrait and photographed on X-ray film by transmitted light, producing a transparent combination of the negative image of the skull with the positive of the portrait.

This method required a minimum of 6 photographic processing operations, considerable time in achieving the correct orientation of the skull and meticulous care in transferring the register marks on the photographs and transparencies.

Minor variations of this method have been described by Furuhata & Yamamoto,[9] who advocate the superimposition of a negative of the skull over a negative of the portrait. When superimposed and printed, a positive image of the skull and portrait will result. These authors also describe a method used at the National Institute of Police Science in Tokyo where selected anthropometric points are marked on the photograph which is then placed on the focusing screen of a camera. The skull is aligned to correspond with the marked points while being viewed through the focusing screen.

Two other variations of the superimposition technique were described by Dalitz in 1974.[10] In one of these, a negative of the skull is superimposed over a positive transparency of the portrait and is then photographed in the usual way. His second method employs an application of the Kodak Tone-line process in which Kodalith Ortho Film Type 3 is used. Positive and negative transparencies of approximately equal contrast are made of the portrait and also of the skull. The negative and positive transparencies of the portrait are then superimposed one above the other in exact register

and a contrast exposure is made on the Kodalith film by oblique light rays from a light source moved around the edges of the image, thus producing a sharp outline on the print. A similar line transparency is made from the positive and negative transparencies of the skull. The resulting outline of the skull is superimposed over the outline of the negative. In this way, the comparison is made in the same manner as was used in the Ruxton case.

An attempt to quantify the comparison in a superimposition was described by Cocks.[11] This method involves marking a number of anthropometric points on the skull. Corresponding points are marked on the portrait and joined to form a series of triangles. The skull is then orientated appropriately and photographed and the points are joined in the same manner as those on the portrait. A transparency, enlarged to the same scale as the portrait, is then made and superimposed in register over the portrait. If the lines and angles drawn between the points on each image coincide exactly, then a positive identity can be concluded.

Although marking anthropometric points on a skull can be achieved with considerable accuracy, errors may be made in determining the corresponding anthropometric points on the one-dimensional portrait. This is due to the thickness of soft tissues and is further complicated by the angulation of the face. The placing of the particular points on the portrait, in such circumstances, may thus be little more than an educated guess and some discrepancies in these points may occur. It will then be impossible to achieve accurate coincidence of the points marked on the skull and the portrait or of the lines and angles if these points are joined. The assumption of a negative result in such a situation could, in fact, be wrong. Even if allowance was made for this possible error, photographs of such a superimposition, if presented in evidence in a court of law, could create doubts about a positive identification.

Considerable difficulties are also encountered in achieving the correct orientation of the skull. Because the image of the skull must be viewed in the camera view-finder, accurate adjustment of the skull is a very tedious task, requiring frequent checks of the image in the view-finder after each adjustment of the skull position. The use of large-format copying cameras with wide focusing screens will aid in this procedure. Mounting the skull upside down on a cradle of plasticine placed on a flat horizontal surface fixed to a tripod will correct the inversion of the image in the camera screen and adjustments to the orientation of the skull can be facilitated by moulding the plasticine. This, of course, will result in a photograph of the skull with the top of the cranium 'cut off' by the plasticine cradle.

A novel adjustable support for the skull was constructed by Dalitz.[12] Thermoplastic dental impression compound was used to create a bed for the base of the skull and a system of calibrated clamps adjustable in 3 planes allowed full movement of the skull which could be fixed in any position.

Orientating the skull was further simplified by Kamijo & Sakai,[13] who constructed a special camera for this purpose. In this technique the skull is mounted in a special clamp activated by remote controls to permit adjustment in any plane. It is then fixed in the selected position. The image of the skull during these adjustments is visible in a viewing screen upon which an image of the portrait is projected simultaneously. The film

recording the superimposition is then exposed automatically. This equipment is very expensive and out of the reach of many laboratories with a small case load.

Difficulties may also be experienced in the interpretation of the completed superimposition photograph because details of critical structures may be masked by other features on the superimposed image.

Video-Superimposition

In an effort to overcome these problems, the present author and his colleagues, in 1977, devised a novel approach to superimposition by utilising video technology[14] (Fig. 1). Two video cameras and a special-effects generator were used to superimpose their images electronically onto a television monitor. The traditional photographic processes were thus eliminated with a considerable saving of time. The skull was mounted through the foramen magnum by a clamp with freedom in 3 axes. Adjustments in orientation of the skull and the determination of the relevant size of the upright images on the screen can be observed on the monitor screen. Added advantages include the provision for fading the images into each other and wiping segments of one image over the other, so that certain characteristics of the skull may be examined in greater detail in relation to the corresponding features of the portrait (Fig. 2). Either image can be reversed to negative form as required to compensate for variations in contrast in the 2 images. This is particularly useful if a skull has been severely blackened by charring in a fire. The entire procedure of adjusting,

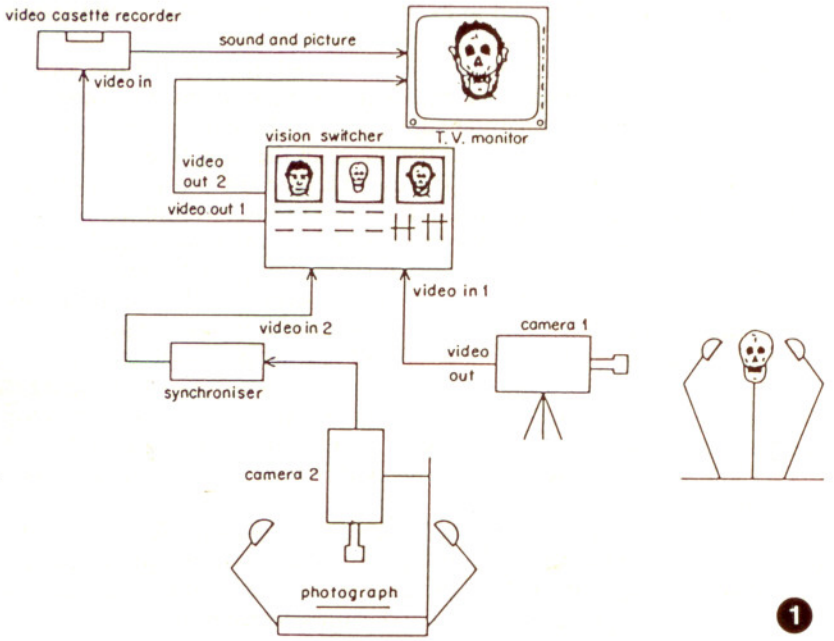

Fig. 1. Scheme for cranio-facial video superimposition.

fading and wiping the images may be recorded on videotape with or without a descriptive commentary. If required, the video tape can be presented in evidence in a court of law.

This method has since been used routinely in the author's laboratory and elsewhere in Australia by Dalitz,[12] Griffiths[15] and Digwood[16] and in New Zealand by Koelmeyer.[17]

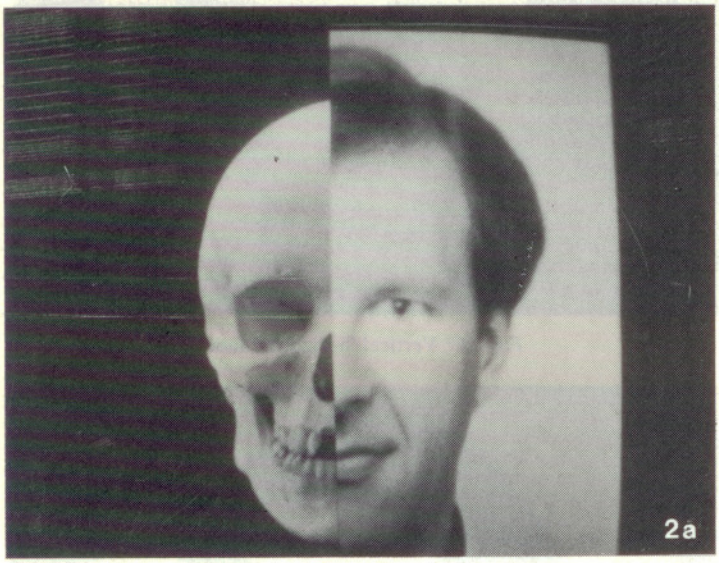

Fig 2A: Vertical fade.

Fig. 2B: Vertical/horizontal fade.

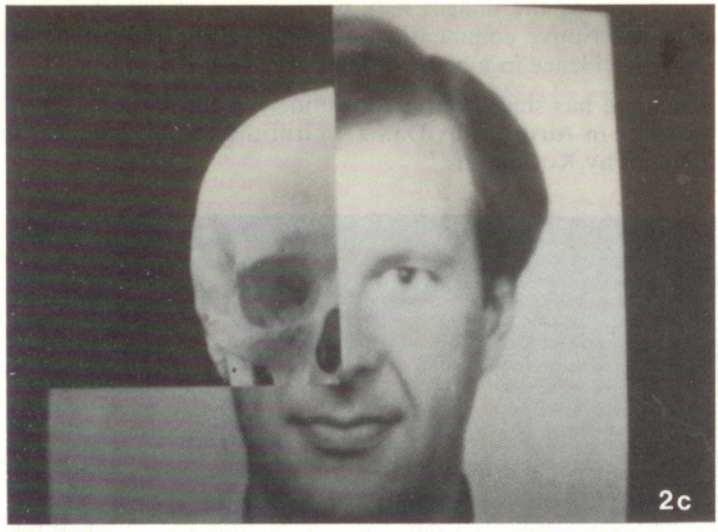

Fig. 2C: Vertical/horizontal fade.

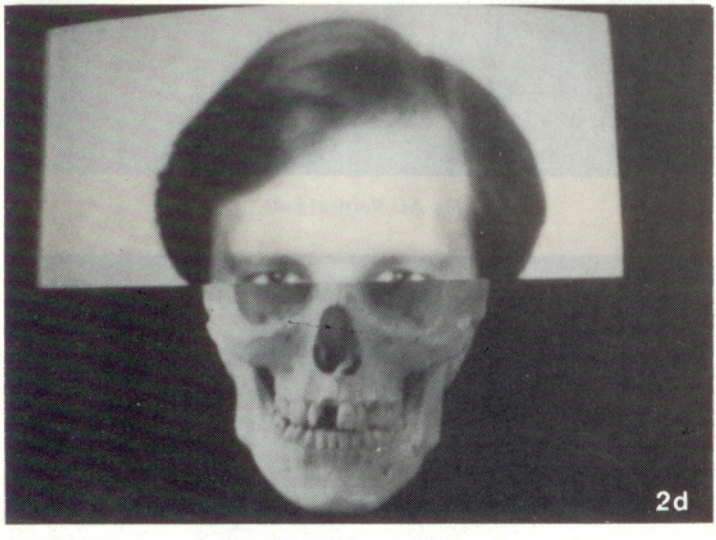

Fig. 2D: Horizontal fade.

Discussion

There is still some controversy about the reliability of superimposition to achieve positive identification. The question was raised at the trial of Ruxton when an objection to the superimposition evidence was overruled by the judge, who admitted it only on the basis that the superimposition 'aided' in 'coming to a conclusion' about the identifications. The appeal judge nevertheless described the evidence of identity as 'overwhelming'.[21] (The superimposition was the only *direct* comparison of the bodies with documentation of known identity.)

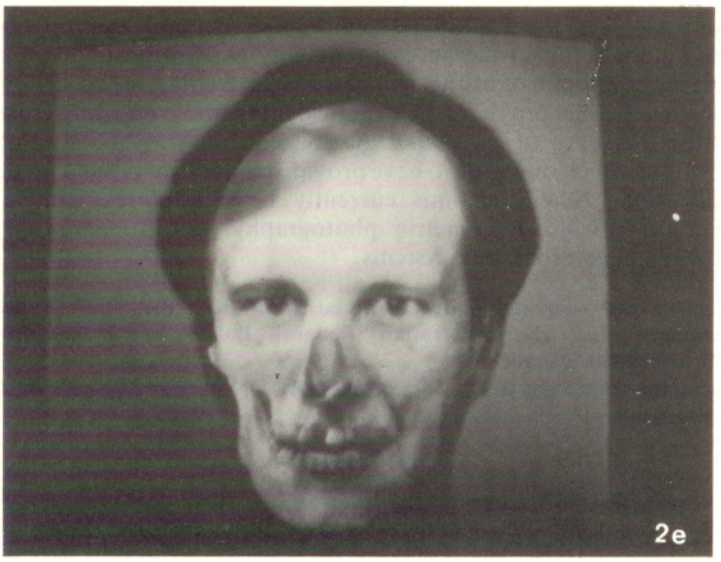

Fig. 2E: Fade.

Devore[18] maintains that, to achieve absolute reliability, it is essential for the photograph of the orientated skull to be taken with the same camera, distance and angulation as the face in the portrait, since it might be possible for 2 skulls to differ only in size. Klonaris & Furue,[8] in agreeing with Devore, recommend further research into the mathematics of camera angulation and object distance so that superimposition 'may provide precise tools for achieving positive identification rather than for general information and orientation'.

However, Kamijo & Sakai[13] describe superimposition as one of the 'powerful methods of individual identification of the unknown skeleton' and Chowdhuri & Majumder[7] describe it as a 'simple, yet reliable method of establishing identity'.

In a recent case in England, Walker[19] reported that photo-superimposition evidence, together with a facial reconstruction by 2 sculptors, was accepted by a Coroner as a satisfactory method of identification.

Koelmeyer[20], in New Zealand, recently used the video method with the addition of a third video camera and radiograph of the skull in 2 cases. In one of these, he claimed that a good match was obtained with a photograph of a person known to be alive. However, the skull was incomplete since no mandible was recovered. He emphasised that the full facial skeleton would be required to obtain any degree of certainty and, on the basis of this experience, he advised that, until the degree of accuracy of this method is determined, it should be used for corroboration only.

It should be stressed that cranio-facial video-superimposition is essentially a modification of the traditional photo-superimposition method. The experience of the present writer covering more than 50 video comparisons has demonstrated that this technique offers distinct

advantages over the traditional photograph method and appears to provide a much higher measure of reliability in identification.

Further development of this technique is proceeding, especially in view of the foreseeable problems in dental identification resulting from the declining incidence of caries and the consequential reduction in dental restorations which, in the past, have provided significant criteria for dental identification. New directions currently being explored include the application of bio-stereometric photography, photo-grammetry and computer image processing systems.

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Special thanks are due to Dr. T. E. Bridges, Mr. D. Eitzen and Mrs. M. Garth for their assistance.

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A Case of Non-Identification by Denture

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The remains of a suspected murder victim were found 22 years after death in a water reservoir.

A complete maxillary denture and some human bones were recovered but no jaws or teeth. The denture was very well preserved and displayed a typical pipe-stem mark but no identification marker. It thus gave no clue to the identity of the victim but contributed to circumstantial evidence which led to closure of the case file.

Key Words: Murder, Denture, Identification Marker.

Introduction

This report emphasizes the urgency of the need to mark dentures. The solution of the case concerned depended entirely on the information contained in a maxillary complete denture which, as it happened, was unmarked and thus unable to reveal the identity of its owner. The case thus remained unresolved by *positive* identification.

Denture marking has been repeatedly advocated[1–5] and many cases of identification have been resolved by denture evidence.[6–8] Most marks fall short of the ideal, but any mark which can lead to a record can be useful.[9]

Case Report

Grahamstown, South Africa, was the scene of the unsolved disappearance (suspected murder) of a 41-year-old man in 1957. The suspected murderer had died of a heart condition shortly afterwards. In 1979, when a farm reservoir was drained, the shell of a motor car containing some bone and a complete maxillary denture was found in it, half buried in the mud.

The Bones

These consisted of an incomplete but representative skeletal collection but without facial bones, jaws or teeth. An anatomist could only express the opinion that they were human and probably male.

The Denture

1. **Materials.** The prosthesis was made of methyl methacrylate resin base and teeth. The base polymer was of the non-spherical type and there was almost no degeneration, discolouration or loss of original polish (Fig. 1). The teeth were probably Metrolux* and the mould and colour were identifiable as 34 and 5 respectively. The latter could easily have darkened but it still fell within the normal colour range.

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* Metrodent Ltd., Huddersfield, England.

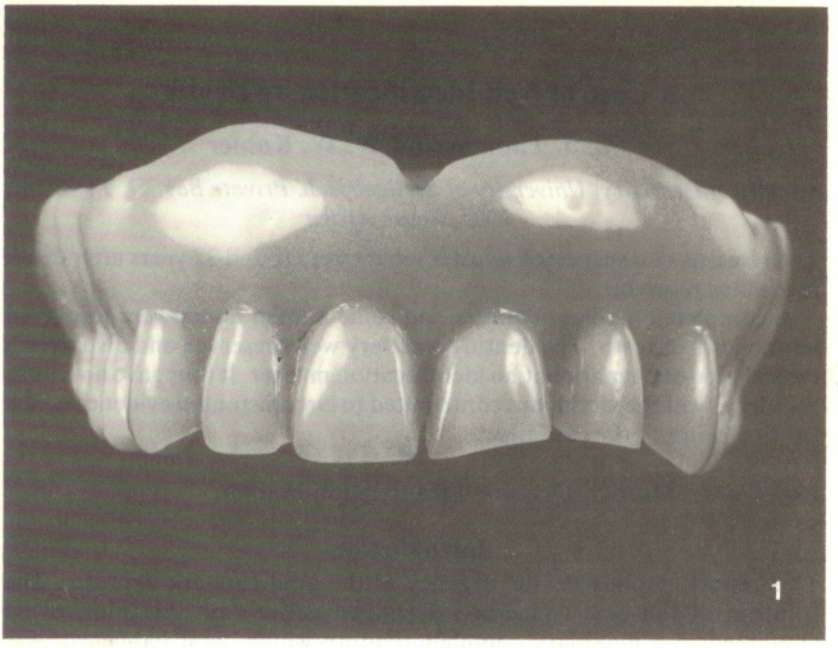

Fig. 1. A frontal view of the denture showing the state of preservation, tooth mould and the pipe stem mark.

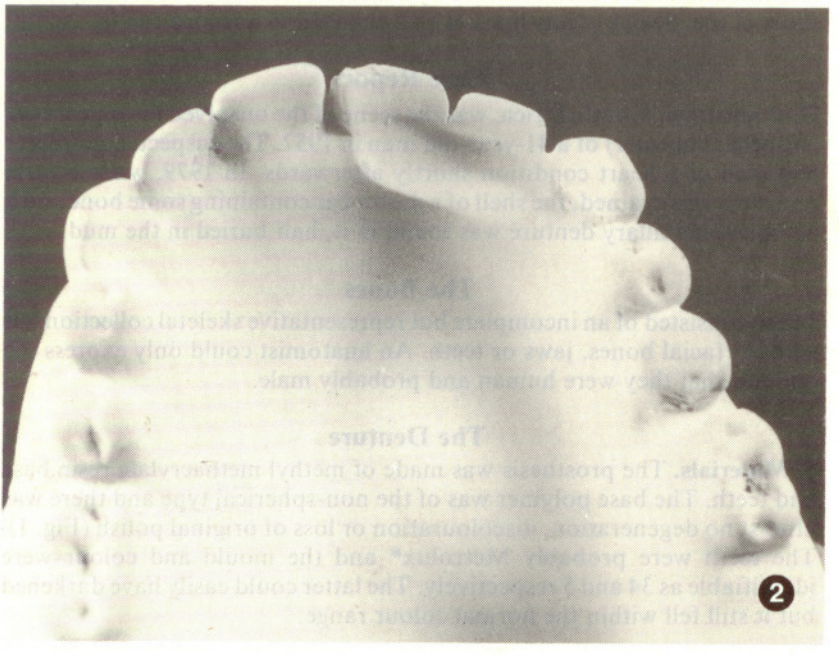

Fig. 2. A plaster cast of the polished surface highlights the pipe stem mark.

2. **Noteworthy features.** These included:

(a) A pipe-stem mark in the anterior left area (Figs. 1, 2).

(b) There was only one molar on each side, one of which (right) was a mandibular molar (Fig. 3).

(c) The occlusal surfaces showed little or no attrition except for the left side (25, 26) (Fig. 3).

(d) A brown tobacco stain occupied the posterior two thirds of the palatal polished surface (Fig. 3).

(e) Staining of the palatal surfaces of 12 and 13 appeared to be caused by a mixture of mud and tobacco (Fig. 3).

(f) Mud deposits were present in the fissures of 24 and 26 (Fig. 3).

(g) A conventional relief chamber (13 x 30 mm) round anteriorly and square posteriorly was present in the fitting surface (Fig. 4).

(h) Palatal rugae were visible, if a little worn (Figs. 4, 5).

(i) A minor amount of toothbrush abrasion of the fitting surface existed (Fig. 4).

(j) A post-dam of usual design had been provided (Fig. 4).

(k) An L-shaped stripe of paler acrylic was observed coursing anteriorly (from mid-posterior palate) and then laterally to the right periphery. It had some, but not all of the features of a repair and was thus not classified as such (Fig. 6).

Discussion

The use of acrylic resin base and teeth points to a date of manufacture well after 1946. The victim died in 1958 at the age of 41 years and since wear of teeth or base was not excessive and the denture could not have been too old, say 3 to 5 years, it was probably constructed between 1953 and 1955. The dentist is no longer available to confirm these deductions.

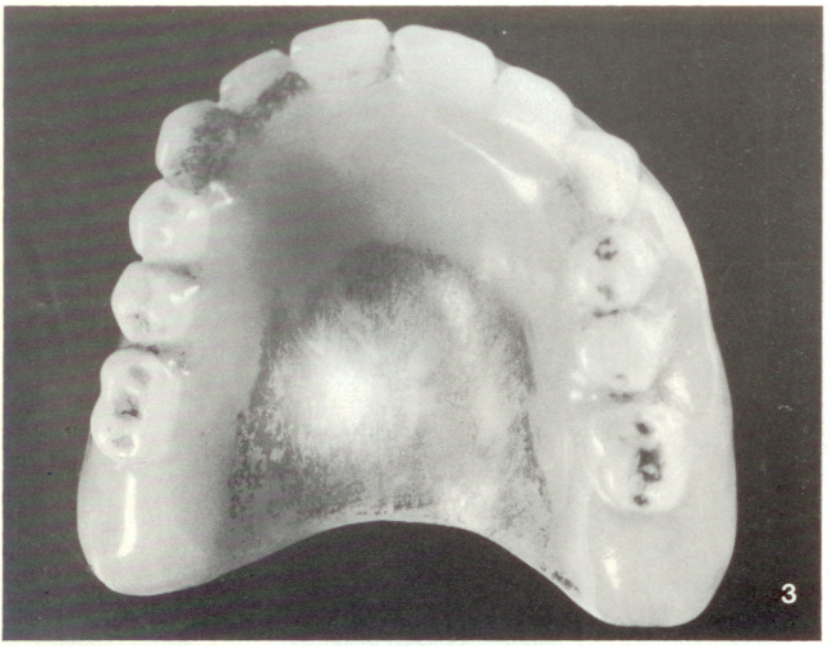

Fig. 3. A view of the polished surface illustrates irregular molar complement, smoke stain and attrition of left second premolar.

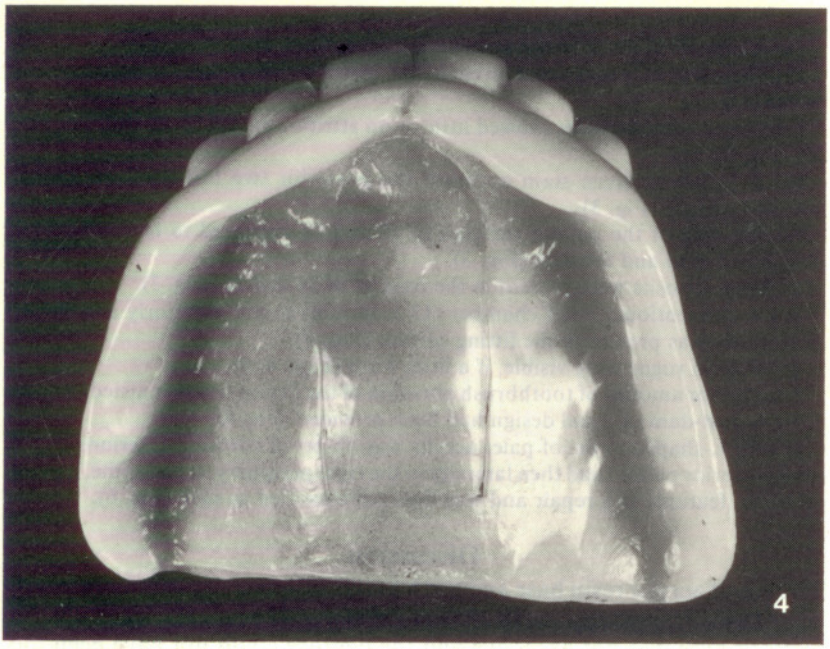

Fig. 4. The fitting surface displays brushing abrasion, the relief chamber and post-dam.

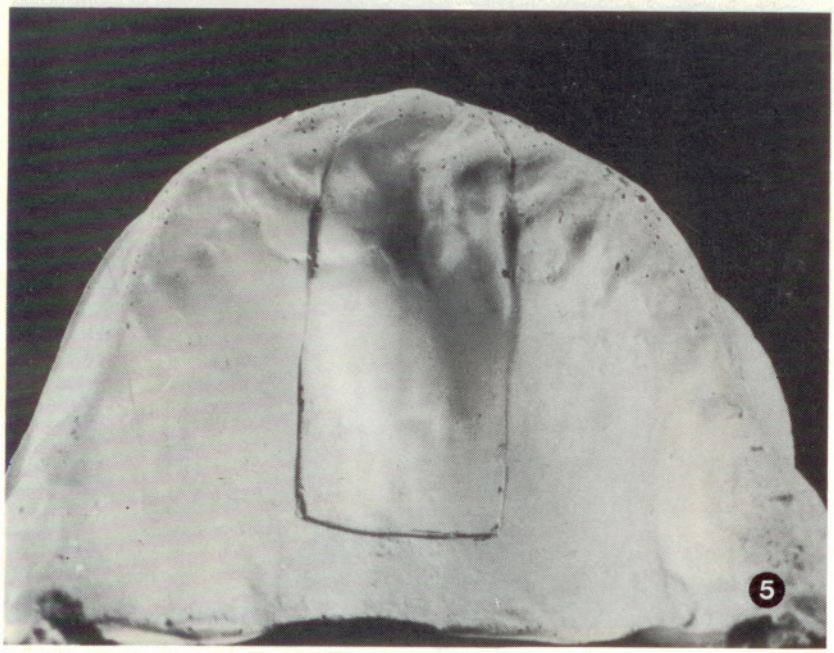

Fig. 5. A plaster cast of the fitting surface highlights the rugae and the relief chamber.

Fig. 6. The L-shaped repair-like mark (arrowed) which was not a repair.

The use of an irregular molar complement and the presence of occlusal wear on the left side only suggested the existence of at least some standing mandibular teeth — perhaps anterior and left posterior, although in that case some teeth should have been recovered. It may, however, have been due to an inexperienced recovery procedure by conventional police officers who would not have been aware of the importance of seeking for small items such as individual teeth.

The pipe stem mark was pronounced and typical and indicated an unvarying left-sided smoking habit.

The anterior teeth had a standard, commonly used shape and size but had an unusual ridge vertically in the middle of each crown (Fig. 7). This was typical of Metrolux teeth and, had a treatment record been available, it would probably have contained the details of tooth selection and could have aided the identification of the denture owner.

The palatal rugae were slightly worn but not sufficiently so to make matching with the ruga pattern in another denture or plaster cast known to belong to the deceased, impossible.

The unusual repair-like mark could have proved very useful had it been a repair because this procedure is one of the few aspects of denture treatment that are regularly recorded and that accord a denture a measure of individuality. Denture repairs have, in fact, contributed significantly to identifications.[10]

A specific denture mark was, however, conspicuous by its absence. Because of its absence, the identity of the victim was arrived at solely by

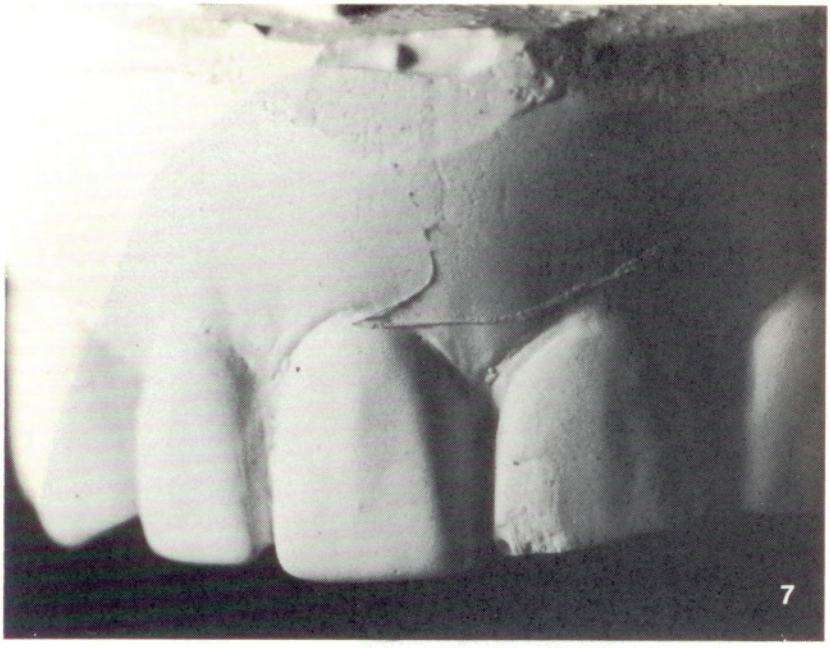

Fig. 7. A plaster cast of the teeth accentuates the typical central ridge found in Metrolux teeth.

circumstantial means. He was known to be a male 41 years old, who had disappeared 22 years before and was a left-handed pipe smoker. The information in the denture was confirmatory and on those grounds alone the case file was closed.

In another case of accidental death followed by incineration,[11] the almost total destruction of the face was described as was the lack of natural or artificial (porcelain) teeth found afterwards on the site. It was concluded that the victim was edentulous but, because of the all-acrylic structure of any dentures that probably were being worn (later confirmed) and the lack of a fire proof identification marker, no useful clues were found to assist in positive identification. Identity was once again achieved by circumstantial means.

A marked denture in both the foregoing cases would have helped considerably although, if of a non-specific nature, would not have yielded information unless a record existed. The ideal mark must speak for itself or must at least be traceable to an institutionalized source such as a central population registry.

The University of Stellenbosch has marked 798 sets of dentures in the period March 1979 to the present. This is a voluntary undertaking and no national legislation exists to enforce the practice in South Africa. Until this happens there will always be the chance that a denture which needs identification, will be unmarked.

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The Pattern of Facial Fractures as an Aid in Forensic Odonto-Stomatology with Special Reference to the Cape Coloured Population Group

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Abstract

Slightly over 1 000 panoramic radiographs of Cape Coloured patients with fractures of the jaws and facial bones, treated in the Department of Maxillo-facial and Oral Surgery, were studied. The exact sites of the fractures were recorded, the etiology was investigated as well as bony pathology in the jaw bones and facial skeleton noted.

Mandibular fractures accounted for 73% of the fractures. The body of the mandible was involved most commonly (34%). In the maxilla the zygomatic bone complex was fractured most frequently (14%). Associated fractures and body injuries were low, possibly because the motor vehicle accident rate was very low (8,5%). The etiology was mainly assault (74%). Consequently court cases followed in a number of cases.

The incidental pathology found in the mandible and maxilla was alarmingly high, if it is borne in mind the patients reported at the Dental Faculty, not because of dental needs, but because of an injury which forced him to seek treatment. The percentage was 48.

The results obtained from the panoramic radiographs were compared with those found on the routine extra oral radiographs normally taken for fractures and found to give more information.

The combination of the fracture pattern of facial bones, combined with incidental pathological findings and etiology, may be a good indicator in forensic odontostomatology.

Key words: Facial fractures; Cape Coloured population group

Introduction

The Cape Coloured population group in South Africa is a hybrid group which has come about as a result of miscegenation between Negro and Malayan slaves, Hottentots, Bushmen and Europeans in the 17th to 19th centuries. The blood-group pattern of the Cape Coloured community constitutes about 34% Western European, 36% Hottentot and Negro and 30% Asian genes[25].

Closely associated with their socio-economic position is alcoholism as an endemic problem. As agricultural labourers in the vineyards of the Cape, they receive a daily measure of wine (the 'tot' system). This results in a regular drinking pattern, which '... habit of drinking to excess,

implanted from generation to generation, is still one of the besetting sins of the Coloured people'.[12] As a result of this children are reared in an atmosphere where use and abuse of alcohol has become a standard pattern of life.

Louw[10] postulated in 1979 that initiating factors of liquor abuse amongst Coloured youths start at a very early age and that 56% of the population who drink alcohol abuse it. In the rest of the world the comparable figure is 15%.

The Theron Commission[23] found that most of the Coloured population group residing in the Cape Peninsula are still at a very low socio-economic level. Fortunately indications are that there is a gradual improvement.

South Africa, although considered part of Westernized society, is also indissolubly part of the Third World. Elements of the First and Third Worlds are consequently found in the culture and mode of living of the people living in South Africa. It is therefore not surprising to find that violence plays a major role in the etiology of facial fractures. In most Westernized countries increased traffic injuries account for an increase in facial fractures.[16] Van Hoof[24] even describes this increase as an epidemic in which cost, disabling factors and the loss of life are staggering. Raffle[7] as well as the National Safety Council of America[16] support this view.

The purpose of this communication is to determine the fracture pattern of the Cape Coloured population group, to assess the etiological factors which play a role and to note the incidental pathological findings of the jaws and facial bones (Fig. 1). The reason for this study was to evaluate the data in assisting forensic odontostomatological studies.

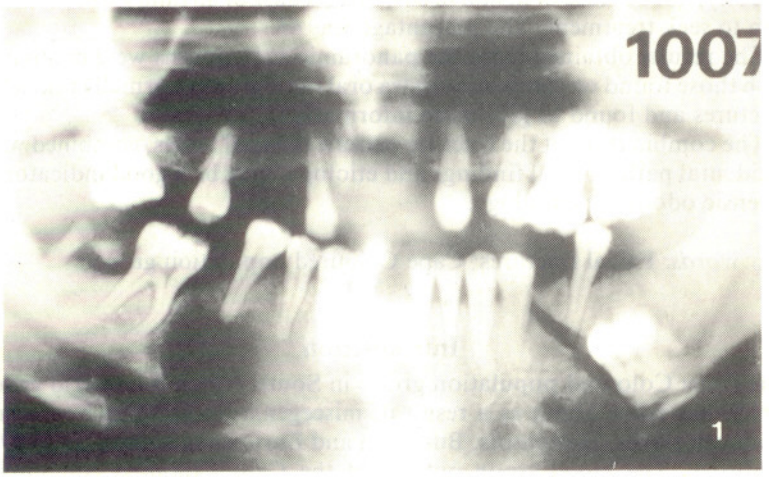

Fig. 1. Pantomograph illustrating a fracture of the jaw as well as bony pathology.

Material and Method

One thousand and seven panoramic radiographs of Coloured patients were examined who were treated by the Department of Maxillo-Facial and Oral Surgery of the Faculty of Dentistry, University of Stellenbosch and the

Tygerberg Traumatic Unit over a period of about 2 years. Some of the patients with minor injuries were treated on an outpatient basis, whereas the more seriously injured patients were hospitalized. The history was obtained from the hospital file.

Results

1. **The Number of patients and division according to sex.** Of the 1 007 patients, 79,2% were males and 20,1% females (a ratio of 3,8 males to every female).

2. **Age Distribution.** Fig. 2 shows the breakdown of the age groups.

3. **Month, Day and Time of Day that Fractures Occurred.** Fig. 3 shows that most accidents occur over the early part of the weekend, between 18h00 and 21h00. The peak months were March - April.

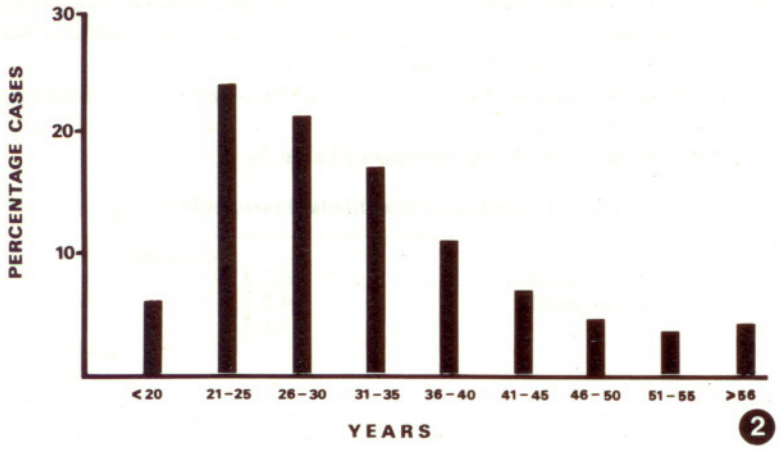

Fig. 2. Age distribution of fractures.

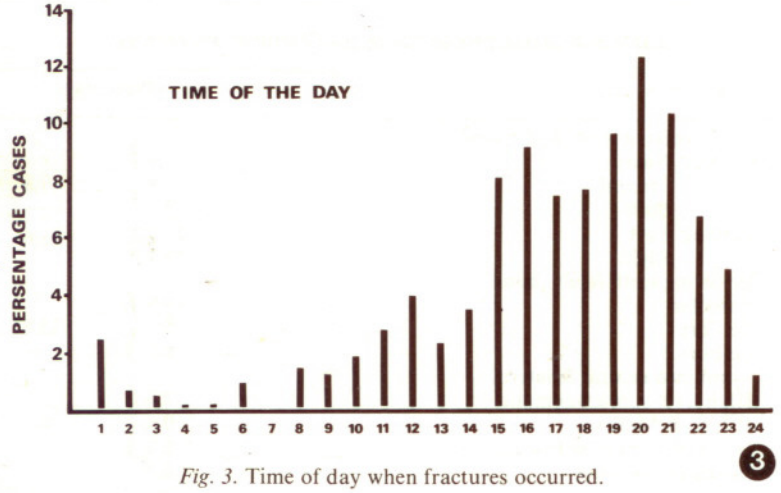

Fig. 3. Time of day when fractures occurred.

Table 1: Number of Fracture Lines Seen on Radiographs

Number of Fractures	*Percentage*
1	34,3
2	37,4
3	14,5
4	5,8
5	3,3
5+	4,7

4. **Number of Fractures.** Every visible fracture line seen on radiographs was counted and read as a fracture (Table 1).

5. **Teeth in the Line of Fracture.** Teeth found in the line of fracture accounted for 57,2% of the cases studied.

6. **The Site of Fractures.** Mandibular fractures were classified according to Rosenberg & Smith[18] whereas the middle-third facial bone fractures were classified according to Rowe & Killey.[19]

6.1 **Mandibular Fractures.** The mandible was involved in 73% of the cases and the site is shown in Table 2.

6.2 **Middle Third Facial Bone Features (Table 3).**

Table 2: Percentage of Mandibular Fractures by Site

Site		*Percentage*	
Condyle	Intracapsular	0,7	15,2
	Extracapsular	14,5	
Angle		17,1	
Body			34,0
Ramus			1,1
Symphysis			4,4
Body/Angle			11,4
Body/Symphysis			8,5
Mental			6,8
Coronoid			1,5

Table 3: Fracture Site of Maxillary Fractures (Percentage)

Fracture Site	*Percentage*	
1. Not involving teeth & alv. bone		
1.1 Central: Nasal	7,1	9,8
Frontal	1,9	
Both	0,8	
1.2 Lateral: Left	31,5	55,6
Right	24,1	
2. Involving teeth & alv. bone		
Alveolar	9,9	23,8
Le Fort 1	5,2	
Le Fort 2	8,7	
3. Combined central & lateral		
High level suprazygomatic	2,8	10,3
H.L.S. & Midline	0,6	
H.L.S. & orbital & frontal	6,9	
4. Inferior orbit only	0,5	

7. Cause. Violence played a major role in the causation of facial bone fractures (Table 4).

Violence can be broken down into more detail (Fig. 4).

Table 4: Percentage Causes of Accidents

Cause of fracture	*Percentage*
Violence	72,2
Fell	12,7
Motor vehicle accidents	8,5
Sport injuries	3,7
Miscellaneous	0,9

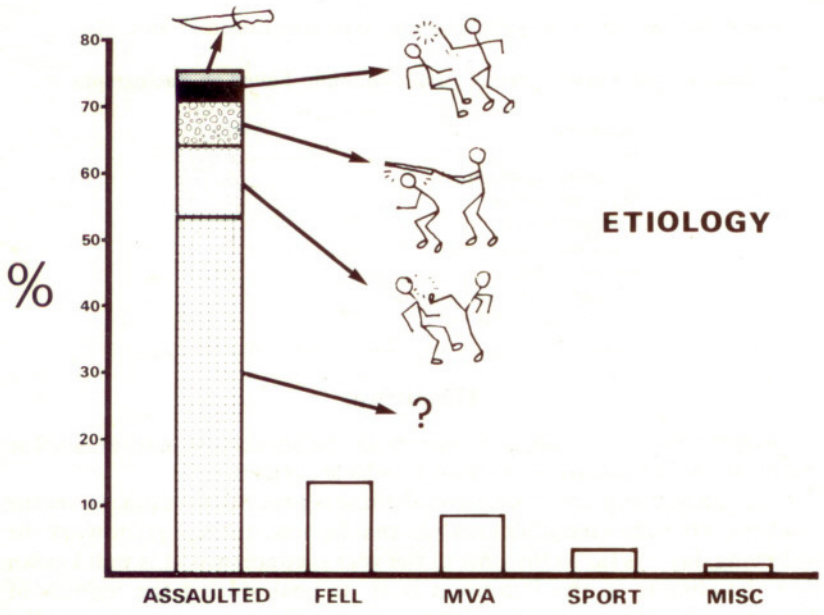

Fig. 4. Causes of violence.

8. **Incidental Pathological Findings.** Tables 5 & 6 shows a breakdown of the pathology found in the jaws.

Table 5: Pathology Found on Pantomographs

Pathology	*Number*
Retained roots	559 (of which 153 was associated with chronic periapical infection)
Teeth with chronic periapical infection (excluding roots)	447
Impacted teeth	121
Cystic lesions	47
Hypercementosis	12
Supernumerary teeth	8

Table 6: A Breakdown of Cystic Conditions Found on Pantomographs

Type of Cyst	*Number*
Residual	19
Dental	7
Unspecified	5
Dentigerous	5
Lateral Periodontal	2
Nasopalatine	2
Incisive canal	2
Kerato	1
Traumatic bone	1
Antral	1

A number of miscellaneous conditions were also found (Table 7).

Table 7: Miscellaneous Pathological Conditions Found on Radiographs

Pathology	*Number*
Condensing osteitis	6
Root resorption	4
Osteosclerosis	3
Taurodontism	3
Osteomyelitis	1
Squamous cell carcinoma	1
Cementifying fibroma	1

Discussion

In most Westernized societies there tends to be an increase in trauma to the facial skeleton from increased motor vehicle accidents.[16]

It can also be expected that alcohol abuse is prone to take place over the weekend when the incumbent realises that he need not report for work the following day. As far as the time of the year is concerned, it is well known that the climate in the Peninsula is at its peak during the months of March-April. This is the time of the year when the hot summer days of the Cape end just before the rainy winter season starts.

Number of fractures

A double fracture line was observed in most cases. This fits in well with the view that a double fracture should always be expected until the contrary proved.

Age Distribution

Most fractures in this study were sustained in the 20 - 30 year old age group (45,4%). The same applies to the study conducted by Spengos *et al.*,[22] although they did not find as many fractures in the second decade. Beaumont's study[2] showed the same tendency for Whites and Asians, but the Blacks tended to fall into a slightly higher age group. Schuchardt, Brichetti and Schwenzer[20] also found the third decade as the highest incidence of the facial bone fracture rate. Rowe and Killey[19] also upheld this view.

Time of the Day, Day of the Week, Month of the Year

Unfortunately not many studies have gone into detail as far as the exact time of the day, etc. when the the injury took place. Whereas Beaumont[2] noted that most fractures occurred during the day, our study clearly indicated that most injuries occurred between the hours of 19h00 to 21h00. This also fits in with the statistics obtained from the Tygerberg Traumatic Unit, where most patients were admitted to the Unit between midnight and 01h00. The time difference is the time taken from the time of injury to get to the hospital. The time of the day when most South Africans take to alcohol is from about 18h00.

Even the compulsory wearing of the seatbelt has not substantially diminished this tendency, especially if the design is of the lap-type. At the Tygerberg Traumatic Unit it was found that 25,8% of all patients seen at the unit had injuries to the lower jaw and facial bones.

Sex Ratio

The male : female ratio of 3.8 :1 is comparable to that found by Spengos, Zotales and Demetroglou,[22] although the number of females involved proves to be higher than that found by Beaumont.[2] This, however, is because Blacks are employed as migrant labourers on the Reef, leaving their families in their homelands.

Teeth in the Line of Fracture

A high percentage of the Cape Coloured population group lose their teeth at a relatively young age (in line with Westernized societies) and this is possibly why a high percentage of fractures occurred through edentulous areas (42,8%).

Site of Fracture

Mandible. This aspect is difficult to compare with findings of other authors because few authors use the same index system. The system is very comprehensive and is to be advocated.

Basically the system advocated by Beaumont[2] is represented by Fig. 5.

Middle Third Facial Bones. The zygomatic bone is involved in most cases.

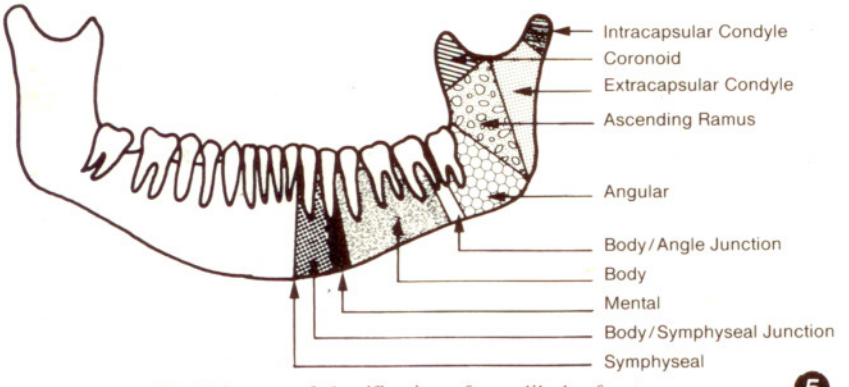

Fig. 5. System of classification of mandibular fractures. 5

Table 8: Fractures in Mandible and Maxilla (Percentages According to Various Authors)

Authors	*Mandible only*	*Maxilla only*	*Condyle*	*Coronoid*	*Ramus*	*Angle*	*Body*	*Symphysis*	*Zygomatic Co.*	*Le Fort I*	*Le Fort II*	*Le Fort III*
Afzelius & Rosen[1]	33	55										
Beaumont[2]	75	25	11	0	3	28	39	18				
Breytenbach *et al.* This paper	73	27	15	1,5	1	29	41	13	56	5	9	10
Muller & Schoeman[14]												
Rowe & Killey[19]	58	33	26			33						
Schuchardt *et al.*[20]	75	21	28		5	19	45					
Spengos *et al.*[22]	54	46	30	1,5	6	19	28	21				

Etiology

The causes of facial fractures found by the various authors are summarised in Table 9.

Table 9

Author	*Group*	*Number of Cases Investigated*	*Findings*
Afzelius & Rosen[1]	Caucasian (Sweden)	271	M.V.A. most common cause
Breytenbach *et al.* This paper	Cape Coloured Group (South Africa)	1 007	Mandible most common site Violence most common cause
Donaldson[5]	Caucasian (New Zealand)	335	M.V.A. most common cause
Duvenage[6]	Caucasoids and Negroid (South Africa)	4 426	
Gwyn *et al.*[8]	Caucasoids and Negroid (U.S.A.)	1 517	
Lindstrom[9]	European Caucasians (Finland)	649	Violence commonest cause
Lundin *et al.*[11]	European Caucasians (Sweden)	899	Violence commonest cause; Relationship with alcohol discussed
Morgan *et al.*[13]	European Caucasians (U.K.)	190	
Muller & Schoeman[14]	Caucasians & Negroid (South Africa)	1 233	Etiology: Blacks: Violence high %; Whites: M.V.A.
Nakamura & Gross[15]	Caucasoid & Negroid (U.S.A.)	323	Violence commonest cause
Rowe & Killey[19]	European Caucasians (U.K.)	1 500	M.V.A. most common cause
Snijman[21]	Caucasoid & Negroid (South Africa)	1 699	Violence commonest cause
Spengos *et al.*[22]	Caucasians (Greece)	432	M.V.A. commonest cause
Schuchardt *et al.*[20]	European Caucasians (N.W. Germany)	1 566	Falls and fights commonest cause

The brilliant research by Réné le Fort in 1901 performed on cadaver heads, subjected to variable degrees of trauma revealed specific fracture lines and planes.

Various publications have made it amply clear that the fracture pattern of the mandible and the facial bones correlates to a large extent with the anatomy of the individual. It is also known that, broadly speaking, the anatomical features of the various races have certain characteristics. It is therefore feasible that the fracture pattern could to some extent determine the race of the subject. Obviously other factors, e.g. the causes of the injury, must be borne in mind.

Incidental Pathological Findings

Cook[4] and Gardner and Stafne[7] pointed out more than half a century ago that radiographs play an important role as an aid in clinical practice. These authors found pathology in between 20% and 30% of edentulous patients studied. Many years later, Donaldson[5] and Bremner and Grant[3] found pathology in the jaws in about 40%. In this study the percentage was even higher, 48%. This apparent increase in pathology findings may be due to improved techniques and more sophisticated equipment rather than an actual increase in pathology.

The diagnosis of most of the conditions found was confirmed by histopathological investigations.

Conclusion

The authors are of the opinion that the pantomograph is of utmost importance as a diagnostic aid in injury cases where forensic odontostomatology is concerned. The radiation hazard is limited if the exposure to ionizing radiation is considered when comparing the combined effect of that of the other extra-oral radiographs.

There must also be a correlation to the bony anatomy of the facial bones (and therefore the race concerned) and the fracture pattern.

The etiology decidedly also plays a major part in the pattern of facial fractures. Violence where sticks, bricks, etc. are used produces a facial bone pattern which differs, e.g. from that produced by a motor vehicle accident. If to these 2 factors, which have an influence on the fracture pattern, are added the bony pathological findings, evidence can be produced which is of great importance in forensic odontostomatology.

Our sincere thanks go to the following persons who helped with this project. Mr. A. Louw, graphic artist, Mrs. J. M. Groenewald for the selection of files and compiling the data and Mrs. Burger for typing the script.

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A Comparison of Two Methods of Tooth Preparation

In a Scanning Electron Microscopy Study of Transparent Root Dentine

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Abstract

Root transparency has been used as the sole criterion in age determination for forensic purposes. Since transparent dentine is thought to result from sclerosis of dentinal tubules, correlation of the circumference of dentinal tubules with the age of the tooth donor might provide an alternative method of determining age from transparent root dentine.

In this preliminary study 2 methods of tooth preparation were compared to determine which allowed optimal visualization of the dentinal tubules as well as careful standardization of the experimental procedure.

The formation of a thick smear layer which could not be removed effectively made the use of undecalcified sections impossible. Best results were obtained using a freeze-fracturing technique. However, variations in the precise plane of fracture, in the plane of fracture of the dentinal tubules and in the density of the tubules make it very difficult to standardise the area from which tubule measurements are taken. This problem will have to be overcome if this method is to be used in future studies.

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Key Words: Forensic odontology; Age determination; Transparent root dentine; Scanning electron microscopy.

The use of structural changes in fully developed and erupted teeth to determine age can largely be attributed to Gustafson,[9] who provided the first scientific assessment of these age-related changes. There have subsequently been numerous publications on each of the 6 age-dependent criteria used by Gustafson. These have been reviewed by Johanson[11], Noble[20] and Altini[1].

It is generally acknowledged that the most useful of the 6 criteria is transparency of the root dentine[11] (Fig. 1). Some investigators have indeed used root transparency as the sole criterion in age determination.[2,12,18,21]

In attempting to find a correlation between transparent dentine and age all the aforementioned investigators concentrated their efforts on measuring the length or surface area of the transparent dentine. However, since transparent dentine is thought to result from progressive sclerosis of dentinal tubules, it seems that a study in which the circumference of

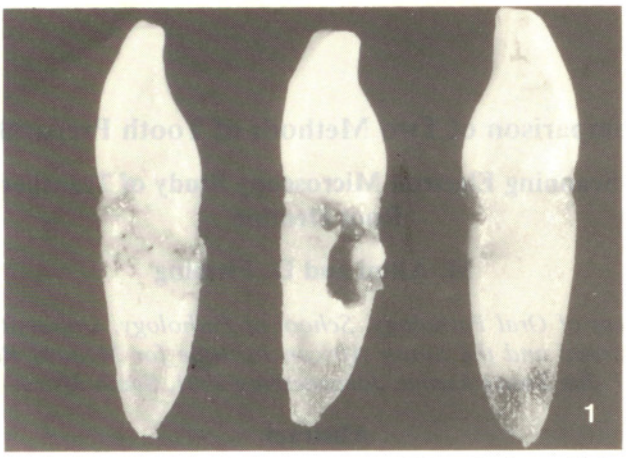

Fig. 1. Mandibular incisors showing transparency of the apical one third of the root.

dentinal tubules was correlated with the age of the tooth donor might provide an alternative, more accurate, more sensitive and easily reproducible method of determining age from transparent root dentine.

Our aim is to measure the diameter or circumference of sclerosing dentinal tubules in transparent dentine close to the root apex in a series of teeth obtained from individuals of varying ages. It is hoped to produce a regression curve which will accurately relate increasing age to decreasing diameter of circumference.

Since the diameter of dentinal tubules varies depending on their proximity to the pulp chamber and may even vary between areas of the root and crown[8] it was necessary to undertake a preliminary study to determine the best method of tooth preparation in order to standardize our experimental procedure carefully. The results of this preliminary study are reported in this paper.

Materials and Methods

The scanning electron microscope (S.E.M.) offers an ideal method for the investigation of dentinal tubules. Two practical methods of tooth preparation are available. The dentine may either be fractured or undecalcified sections may be prepared. Both these methods were used in this study.

Twenty caries-free single-rooted human teeth were obtained and stored in 10% formol saline to prevent drying out. Five of these teeth were subsequently quenched in liquid nitrogen for 3 - 5 minutes, placed in a bench vice and fractured. In an attempt to influence the plane of fracture, a superficial groove was cut longitudinally into the root surface of another 5 teeth before being freeze-fractured in the same manner. The apical one third of the fractured roots was carefully separated and prepared for viewing with the S.E.M.

The remaining 10 teeth were embedded in a clear acrylic resin (Crystic N7036), after which longitudinal sections were cut at a thickness of 200 microns in a bucco-lingual plane through the pulp chamber. A low speed

saw (Isomet*) with a water-cooled, diamond-impregnated rotary cutting disc was used. The apical one third of the root was cut off from each section. Because the formation of a smear layer was anticipated, it was decided to treat the specimens thus obtained as follows:

The sections were separated into 4 groups. Specimens in Group 1 were simply stored in a moist medium, while specimens in Group 2 were washed in running tap water for 6 hours before being similarly stored. Group 3 specimens were placed in ethylenediaminetetra acetic acid (E.D.T.A.) and Group 4 specimens in 10% formic acid for up to 6 hours before being washed in running water for a further 6 hours. All the specimens were then prepared simultaneously for S.E.M., A J.S.M. T20 scanning electron microscope was used to view the specimens.

Results

All the teeth which were freeze-fractured split open longitudinally through the pulp chamber. Cutting superficial grooves did not influence the plane of fracture. The fracture line did not always pass precisely through the apex of the root which, on occasion, was excluded from the fracture entirely. Examination of the freeze-fractured specimens yielded consistently good results in that both transversely and longitudinally fractured tubules could be seen clearly in all specimens (Figs. 2, 3). Little surface debris was present and the outline of the tubules was very clear. While the S.E.M. permits measurement of the distance from the apex and/or pulp chamber to selected points, variations in the precise plane of fracture, in the plane of fracture of the tubules and in the density of the tubules made it very difficult indeed to standardize the precise area from which tubule measurements were to be taken.

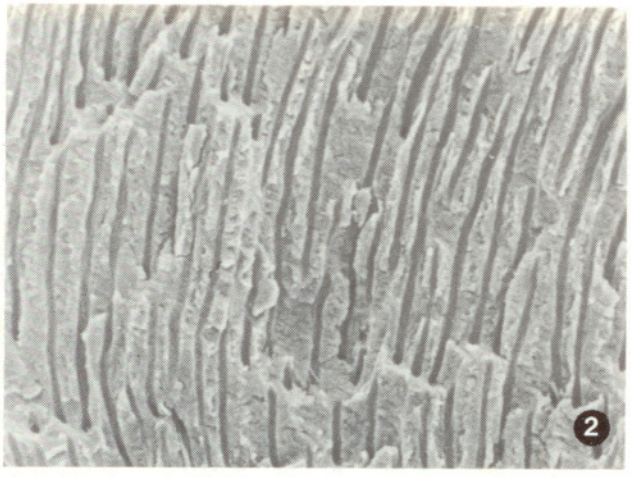

Fig. 2. Dentinal tubules fractured longitudinally (Original magnification x 750).

*Isomet T.M. 11-1180 Low Speed Saw. Buehler Ltd., Illinois, U.S.A.

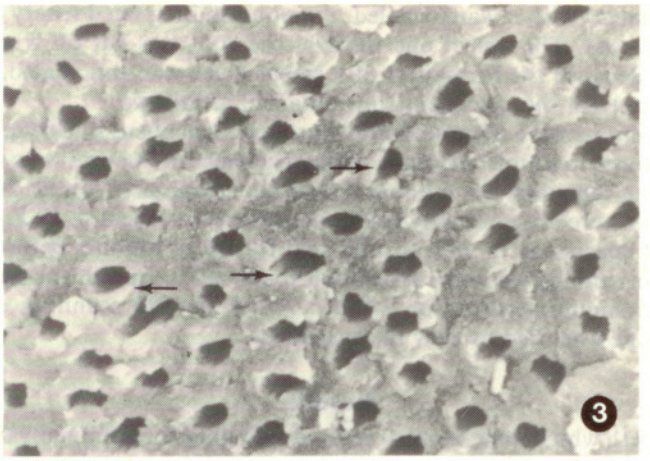

Fig. 3. Dentinal tubules fractured transversely. Highly mineralised peritubular dentine is evident around some of the tubules (arrowed). (Original magnification x 2000).

In contrast, examination of the undecalcified sections yielded very poor results. All the specimens were covered by a dense smear layer which effectively obliterated most of the tubules. Washing the specimens in running water was totally ineffective in removing the smear layer (Fig. 4). Immersion of the specimens in 10% formic acid or in E.D.T.A. was only slightly effective in removing the smear layer. Occasional dentinal tubules could now be seen. However, the outline of the tubules was indistinct, there was extensive etching of the intertubular dentine and the peritubular dentine was completely lost (Fig. 5, 6).

Fig. 4. This section was washed in running water for 6 hours before being processed for S.E.M. The smear layer has remained virtually intact, completely obliterating all the dentinal tubules. (Original magnification x 2000).

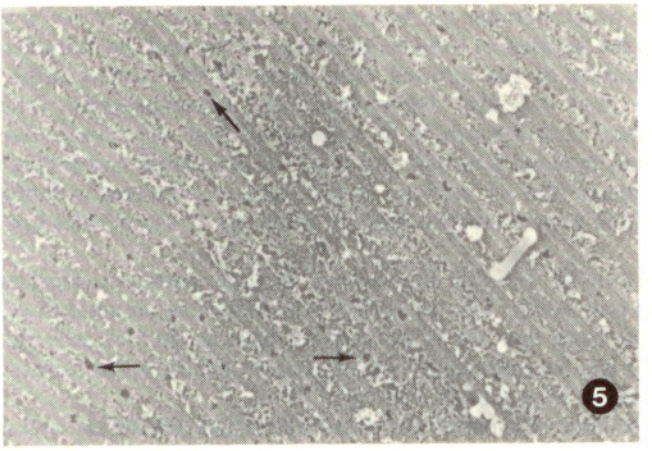

Fig. 5. Immersion of the sections in 10% formic acid for up to 6 hours resulted only in slight removal of the smear layer. Some dentinal tubules are now evident (arrowed). (Original magnification x 1000).

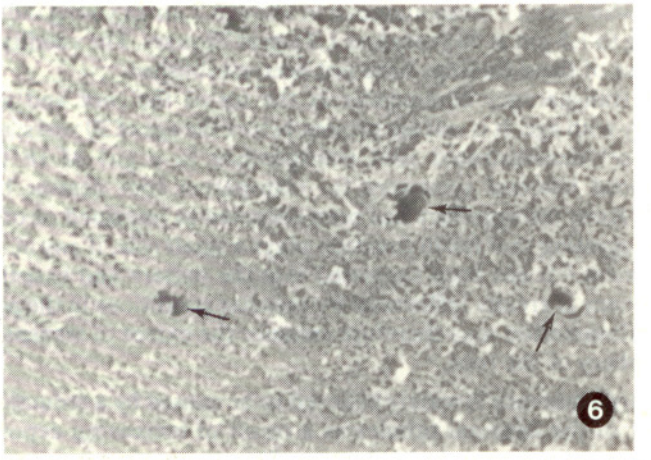

Fig. 6. E.D.T.A. was slightly effective in removing the smear layer in that occasional dentinal tubules can be seen (arrowed). However, the outline of the tubules is indistinct and extensive etching of the intertubular dentine is evident. Peritubular dentine is completely lost. (Original magnification x 2000).

Discussion

Several studies have measured the diameter of dentinal tubules. Those performed on decalcified human dentine using light microscopy[4,14,17] can largely be discounted since it has clearly been shown that peritubular dentine is totally dissolved during acid decalcification. Thus tubule diameters measured from decalcified dentine are excessively high. In addition, histological processing of decalcified dentine results in about 18% shrinkage for which correction to measurements must be made.[5]

In an S.E.M. study of fractured coronal dentine at various distances

from the pulp chamber Garberoglio and Brännström[8] showed that near the pulp the number of tubules/mm² was 45 000 and the diameter 2,5 μm; in the middle of the dentine there were 29 500 tubules/mm² and the diameter was 1,2 μm. Peripherally the corresponding values were 20 000/mm² and 0,9 μm. It is interesting that the tubule diameter in decalcified sections is almost the same for peripheral and pulpal dentine. This suggests that an increase in thickness of peritubular dentine is the cause of the continuous decrease in diameter of the tubules towards the enamel.

Occlusion of tubules in coronal dentine increases markedly with attrition and caries. This occlusion is produced by mineral deposition in crystalline form and not by peritubular dentine. In fact, true peritubular dentine is not formed rapidly in response to attrition and caries; nor does its deposition vary greatly with age.[15,16]

Similar data relating to the size of dentinal tubules as well as to the occlusion of the tubules in root dentine is, to the best of our knowledge, not available although it has been stated that in root dentine the overall diameter of the tubules is smaller than for crown dentine.[19]

The only previous study relating tubule diameter to age is that of de Jonge[13] who found a mean diameter of about 3,2 μm in young individuals, changing to 1,5 μm at 50 years and 1,2 μm at 70 years. The validity and the usefulness of these findings have not been established.

Root transparency commences at the tip of the root and advances coronally with age. It is seldom present before the age of 30 years, although Johanson[11] demonstrated root transparency in a girl of 18 years. A pronounced bilateral symmetry for transparent root dentine has been found.[19] Root transparency has been observed in impacted or unerupted teeth, suggesting that tooth function plays a small role, if any at all, in its development.[2] It has been suggested that the pattern and extent of root transparency is greatly influenced by vascular conditions in the periodontium. Inflammation may therefore enhance the extent of transparency at the periphery of the root.

Root transparency is widely believed to be caused by a reduction in the diameter of the dentinal tubules as a result of increasing deposition of highly mineralised peritubular dentine. This assumption is not supported by the findings of Brinkmann and Hartmann[3] who, using a highly sensitive photon beam absorption technique, showed no significant age dependency of the roots' mineral content; nor were they able to show any correlation between the extent of transparency and the mineral content.

Accordingly, they suggested that other mechanisms must explain the decrease in the lumen of the dentinal tubule. In this regard the demonstration by Mendis and Darling[16] that sclerotic coronal dentinal tubules related to attrition and caries were occluded not by peritubular dentine but by cuboid or rhomboid crystals of varying size, might be pertinent. Different mechanisms might be responsible for producing transparency under various conditions so that in the transparency under caries a different mechanism may be involved from that in apical sclerosis.[19]

It is well known that grinding debris deposits in the form of a smear layer on dentinal walls with cavity preparation. This smear layer effectively

obliterates the dentinal tubules. We anticipated similar problems in our undecalcified sections and hence decided to pre-treat the sections in various ways in an attempt to dislodge the smear layer. As can be seen from our results, running water was totally ineffective while 10% formic acid and E.D.T.A. were only slightly effective in removing the smear layer. Clear visualization of the dentinal tubules was therefore impossible.

The use of various conditioners, cleaning agents and etching solutions in removal of the smear layer from dentinal walls following cavity preparation has been studied extensively.[6,7,10] The ability of diamond instruments to produce extensive well-retained amorphous surface smear layers and the failure of non-acid cleansing solutions to remove this smear layer effectively has been documented.[6] Acid-etching solutions may effectively remove the smear layer. However, immediate loss of peritubular dentine will widen the tubular apertures as much as 3 times.[6] In our study, failure to remove the smear layer may be related to the fact that acrylic particles from the embedding medium must have contributed substantially to the smear layer.

The freeze-fracturing technique yielded the best results and offers an acceptable method of tooth preparation for measurement of dentinal tubules. However, standardization of the area from which tubule measurements are to be taken is very difficult. This problem will have to be overcome if this method is to be used in future studies.

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The Identification of 2 Victims of Fire

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Many different methods can be employed to establish the identity of persons. In many cases, less dependable methods are used in conjunction with more specific methods in order to arrive at the correct identification (acceptable medical certainty).

The method or methods used depends upon the post-mortem condition of the body and/or the available ante-mortem data which can be used for comparison.

The methods include:

1. *Less dependable methods:*

(a) Visual identification (recognition);
(b) Personal effects such as clothing.

2. *Scientific methods:*

(a) Fingerprints;
(b) Dental characteristics;
(c) Skeletal characteristics;
(d) Medical conditions;
(e) Serology;
(f) Hair.

3. *Identification by exclusion* (Sopher[3])

All the methods depend on comparison.

The more specific and most scientific methods are those of finger prints and dental characteristics. Only these 2 are specific for the individual[3].

Positive identification of victims of fire depends largely on the extent, type and duration of the fire. In many cases the dental identification is the only reliable method.

Teeth are very resistant to slow application of heat but, if subjected to rapid and severe heat, they disintegrate. In severe burns, the cranial roof is the first part of the skull to be damaged, followed by the brain. The last to be affected is the mouth, especially the teeth, which are protected by the tongue, lips and cheeks and the steaming of the saliva (Harvey[2]).

It is noteworthy that if the victim is already dead before being burned, the teeth and the oral cavity are better preserved than when the victim of fire was still alive when burned (Gustafson[1]).

Sopher[3] states:

'One of the many ironic aspects of the natural world is that the human dentition, the site of prevalent, chronic breakdown in life, outlasts all other body tissues after death.'

Key words: Identification, Dental records, Fire

Fig. 1. The severely burned body of one of the victims. (H: head; T: thorax; L: leg).

For this reliable method of dental identification, the cardinal factor of importance is the availability of ante-mortem records.

The object of this paper is to stress the importance of the availability of reliable ante-mortem records. I quote 2 cases illustrating how dental identification could be facilitated and made positively reliable when ante-mortem records are available.

Two cars were involved in a head-on collision. One car caught fire and was totally burnt-out. The 2 occupants of the car were so badly burned that, on initial examination, it was only possible to show that they were male, and this only after a deep incision into the pelvis revealed tissues of the penis.

The damage to the bodies was so extensive that the limbs were almost totally destroyed, the thorax and the abdomen were agape while the organs were burnt and destroyed almost through to the back (Fig. 1). The skulls were extensively burnt with destruction of the roof of the cranium and brain (Fig. 2). No skin could be discerned.

The car was positively identified as belonging to a Mr H. H. who was 29 years old and who had long hair.

An eye-witness had seen that there were 2 persons in the car and that the passenger sitting in the left front seat had long hair, while the driver appeared to be younger and definitely had short hair.

After the accident, a buckle of a belt, a trousers clip, melted spectacles and melted money were found on the driver. Further, 2 keys and a badge of a military unit were also found. After further investigation it was ascertained that a person was missing from the particular military unit and that the keys belonged to his tin trunk and cricket bag.

It appeared obvious that there were 2 persons and there was a strong indication who they were, the 2 being, Mr J. T. (20 years old) and Mr H. H. (29 years old).

The problem was which of the 2 was the driver.

As a result of the extensive damage caused by the fire and in order to distinguish the driver from the passenger, dental examination remained the only possible way to clarify the identification problem.

The 2 bodies were examined at the government mortuary and no information was given to the author regarding their identity.

At the post mortem examination the following were *in situ*.

Fig. 2. The body of victim B showing extensive damage. (B: brain; the arrow indicates the maxilla).

Case A. The maxilla from midline to the tuberosity of the right side with the following teeth — 15, 16, 17, 18 (Fig. 3). There was no soft tissue in relation to the maxilla.

Mandible: condyle and ramus with last molar right. The rest of the mandible was not found.

Case B. Maxilla: more complete than Case A with partial protection of the posterior area by the tongue. There was no recognisable soft tissue in the anterior area and there was loss of alveolar bone labially. The palatal side was intact.

Teeth present in the maxilla were 14, 15, 17, 18 (with a buccal cavity), 24, 25, 26, 27 and 28 (with a buccal cavity).

Fig. 3. Maxilla of victim A; only the right half of the maxilla was intact. (T: tongue, P: palate).

Mandible: posterior 3 cm of the body of the left side together with the ramus and condyle. Teeth present were 37 and 38. The rest of the mandible was found elsewhere in the body.

Further, a number of loose fragments of bone and teeth were found on the bodies, mostly in the upper part of the thorax but also as low down as the pelvic area.

Jaw and tooth tissues of the 2 victims, found *post mortem*, are shown in Figs. 4 and 5.

With regard to age estimation the following were found *post mortem:*

Case A (Fig. 6): 18: in normal position, distally inclined; 28: roots incompletely developed; 38: not found; 48: did not develop.

Case B: All third molars in fully erupted position, 18 and 28 revealing buccal cavities.

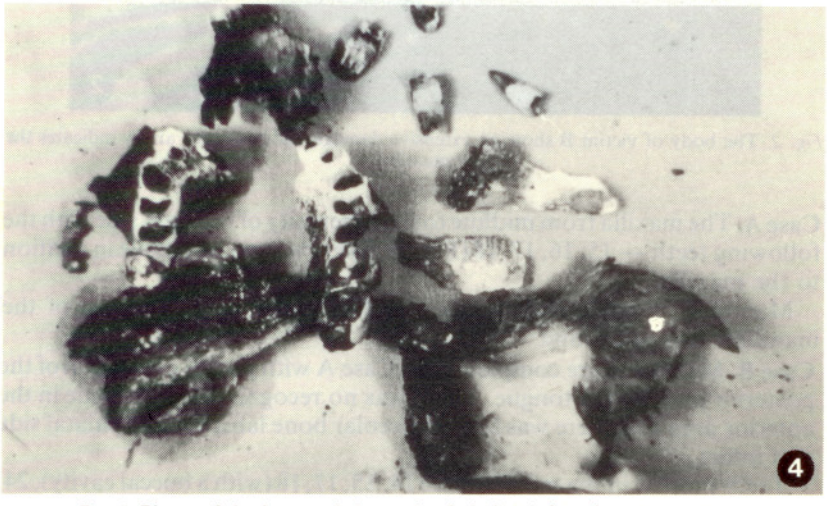

Fig. 4. Pieces of the jaws and the teeth of victim A found *post mortem*.

Fig. 5. Maxilla, parts of the mandible and the teeth of victim B found *post mortem*.

Fig. 6. Case A. Third molar (28) not fully erupted (arrow).

Consequently there was a strong indication that A was the younger (20 years) and B the elder (29 years).

This finding agreed precisely with the suspicions of the police. According to them A (Mr J. T.) was the driver and B (Mr H. H.) the passenger.

This agreed further with the following:

1. What the eye-witness saw, viz. that the younger man was the driver.
2. The man who had long hair corresponded with passenger B, i.e. the elder.
3. The keys were found on A who was the younger.

After the correlation of all the findings it was possible to establish that A could be buried as Mr J. T. and B as Mr H. H.

For further comprehensive examination the jaws were removed (in the prescribed way) and together with all the loose pieces were taken to the laboratory.

Comprehensive examination revealed the following features suitable for identification purposes:

1. *Mr J. T.:*

14: 2 roots.
15: MOD amalgam.
16: MOD amalgam (Fig. 7);
mesiobuccal root curve 3 mm from apex.
17: MODBP amalgam.
26: mesiobuccal root curve.
27: mesiobuccal root curve;
distobuccal root curve.
18: distal inclination.
28: roots partially developed.
A MO or DO amalgam filling from the mandible.

2. *Mr H. H.:*

15: distal curve 3 mm from apex of root.

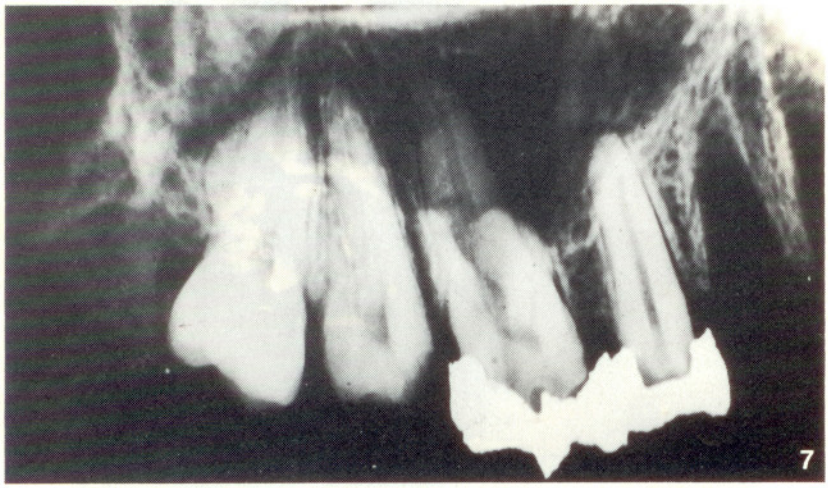

Fig. 7. Rontgenogram of the maxilla of case A (Mr J. T.) showing MOD amalgam restorations on 15 and 16.

16: mesiobuccal root showed hypercementoses.
18: large buccal cavity.
26: occlusal amalgam filling.
28: large buccal cavity.
44: previously extracted (space of 8 mm between 43 and 45).
45: prominent anterior curve (Fig. 8).
36: previously extracted.

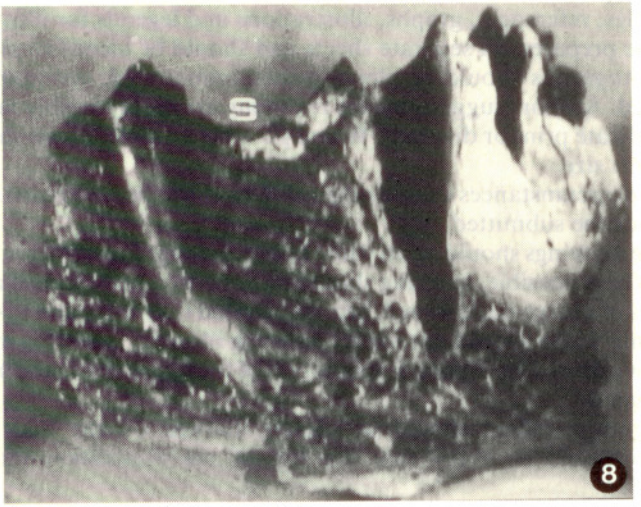

Fig. 8. Prominent anterior root curve of 45. Space (S) between 43 and 45.

With the abovementioned details at hand, an extensive search was launched for ante-mortem dental records.

In spite of a country-wide search, only the following details in relation to Mr J. T. were found. On 19 May 1980 (18 months before the accident) he was examined and the cavities requiring restoration were indicated as follows:

14: distal cavity.
35: distal cavity.
36: buccal cavity.

No further records of either of the victims of the fire could be traced.

In spite of severe burn damage to the body and the jaws, it was possible, in this case, to differentiate between 2 persons solely on the grounds of visual observations.

Although finality could be reached in these cases, they remain good examples of the problems with which the forensic odontologist is confronted when ante-mortem records are incomplete.

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