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Contents

THE VALUE OF THE FRONTAL SINUS IN IDENTIFICATION OF UNKNOWN PERSONS

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Abstract

The reliability of comparing ante- and post-mortem radiographs of the frontal sinus as an identification medium for unknown corpses was tested by means of two radiographs each of 99 individuals. Three independent observers attempted to blind match each pair of radiographs. The results were almost 100% successful and showed that the radiographic image of the frontal sinus, even with varying beam angulation and radiological inexperience of observer is an effective identification medium.

Key words: sinus frontalis, radiography, person identification.

Introduction

The frontal sinus does not exist in man at birth and only begins developing during the first years, increasing in size and complexity until about 20 years. After that minor changes in its pattern may take place as a result of aging or disease. In about 4-5% of individuals the sinus is missing, possibly associated with non-union of a metopic skull suture. In all other cases it is well known that there are marked individual differences in its pattern which will not be affected by possible sex and racial differences. All individuals seem to have their own unique pattern of the frontal sinus[1-5] and as early as 1931 Thomas A. Poole stated that no two persons have identical frontal sinus configurations.[1]

Different classification methods have been used to describe the frontal sinus as seen in a radiograph.[3,6,7] Usually, no special sinus projection is needed and a standard antero-posterior view is sufficient. Most of these methods are based on the size, shape and symmetry of the sinus, as seen in the antero-posterior skull radiograph. Using any of these classification methods the sinus can be almost as useful as fingerprints in identifying unknown persons. If there is a doubt as to the identity of the deceased, the ante-mortem radiographs can be searched for in hospital files which, if luck will have it, the individual will have been admitted for a skull fracture or tumour or other diseases of the head. Two major antero-posterior projections are generally used in hospitals: the occipito-mental (Caldwell) and the occipito-frontal (Wallers). According to Asherson[8] the occipito-mental projection is the most accurate method and the most suitable for obtaining identical views of the frontal sinuses, even if different radiographers are used.

As far as we know, no studies have been performed to study the configuration of sinus frontalis over a period of years with identification purposes in view.

The aims of the present study were to test the reliability of sinus frontalis radiographs for identification purposes and to compare the competence of observers at different levels of training and experience to read the radiographs.

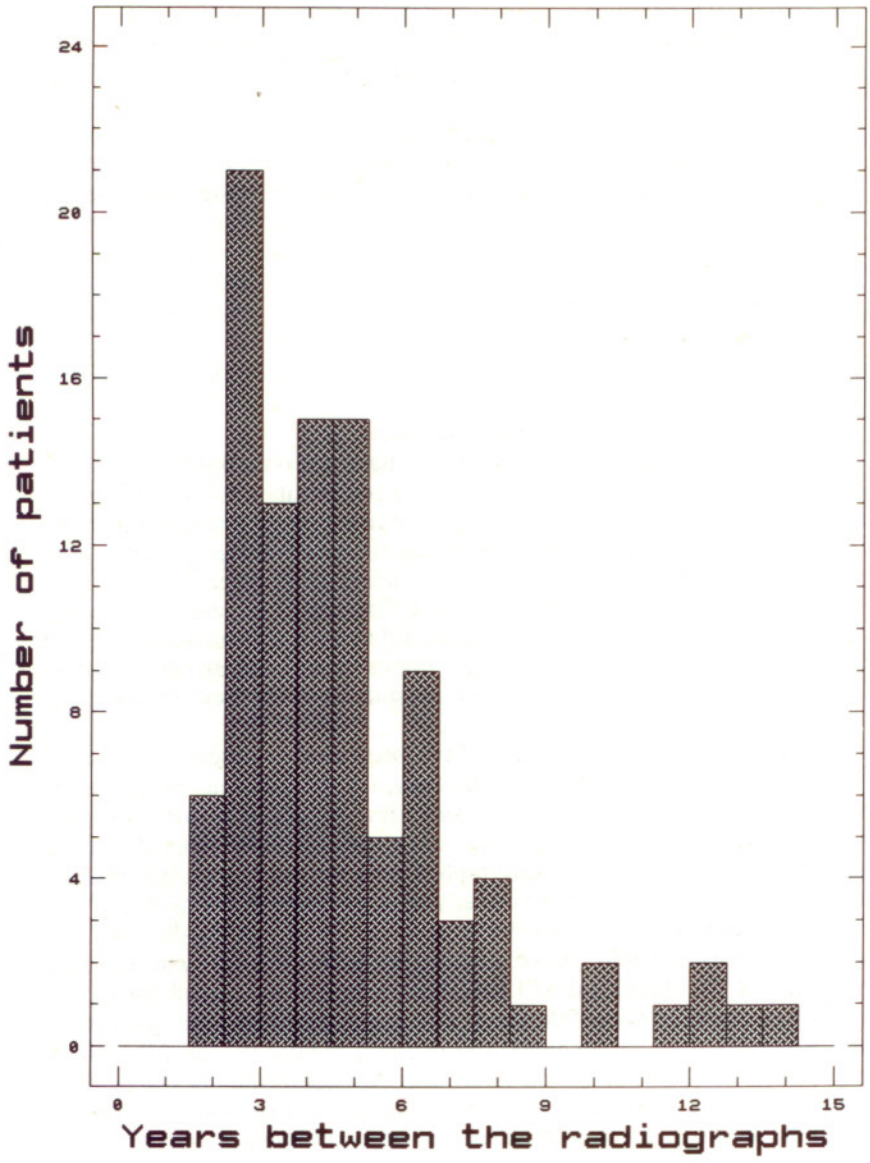

Fig. 1 Number of patients and differences in time intervals between the two radiographic examinations.

Material and methods

The material consisted of antero-posterior skull radiographs of 72 female and 28 male patients, made on two occasions at the department of Neuro-radiology, Karolinska Sjukhuset, Stockholm. The radiographs were selected randomly from a large sample of patients who had been followed-up with repeated, identically projected skull radiographs for long periods during treatment of small, mostly hypophyseal, endocranial tumours.

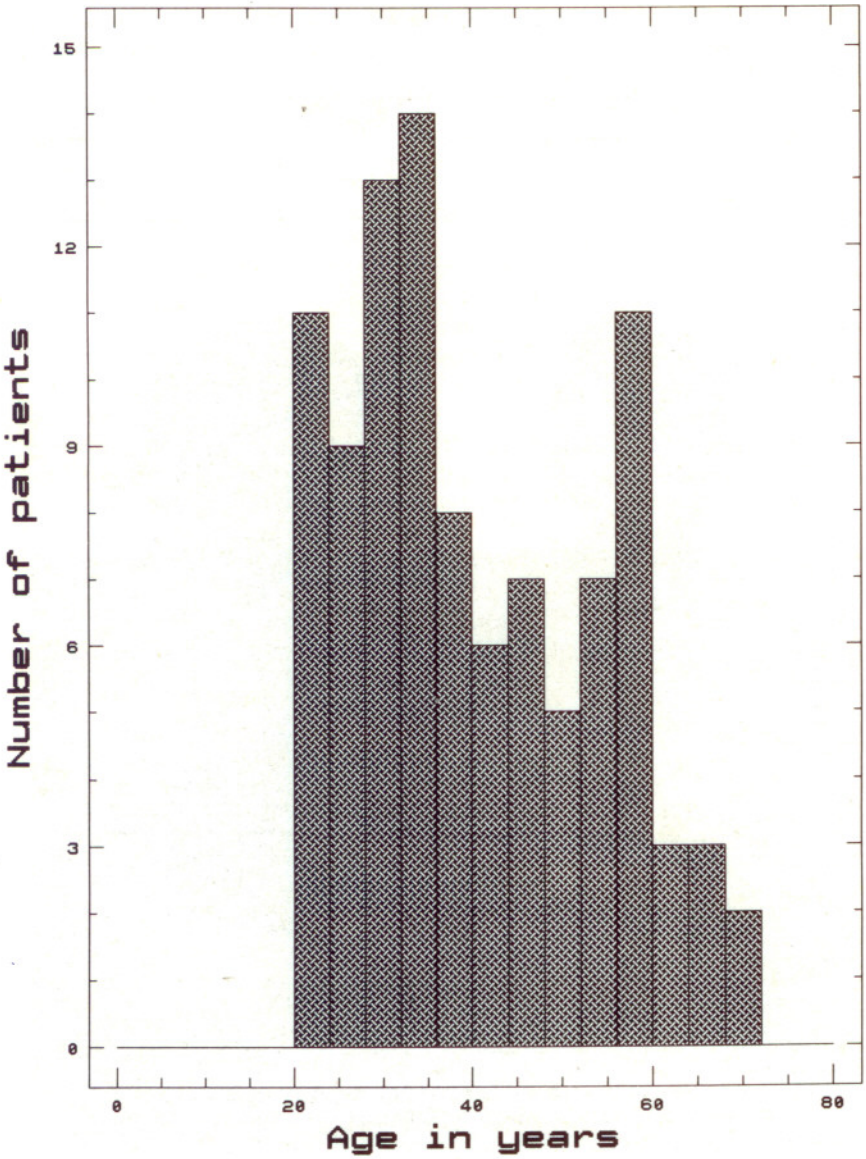

Fig. 2 Number of patients in age groups at the first radiographic examination.

There were no persons in whom sinus frontalis was missing. The average time interval between radiographs was 4.9 years (Fig. 1) and the average age of the patients at the time of the first radiograph was 40.6 years (Fig. 2). The antero-posterior radiographs had been made with an ORBIX* and the exposures were 80 kV and 32 mA with an average exposure time of 0.18 seconds. The frontal projections were similar to Wallers' occipito-frontal view (Fig. 3).

Two sets of radiographs were used, 100 which had been taken at the first visit ("simulated ante-mortems"), and 100 taken at least two years later ("simulated post-mortems"). The "post-mortem" radiographs were coded, de-identified and randomly mixed.

Three observers (R.G., B.E. and L.K.) working completely independently attempted to match each "post-mortem" radiograph with the corresponding

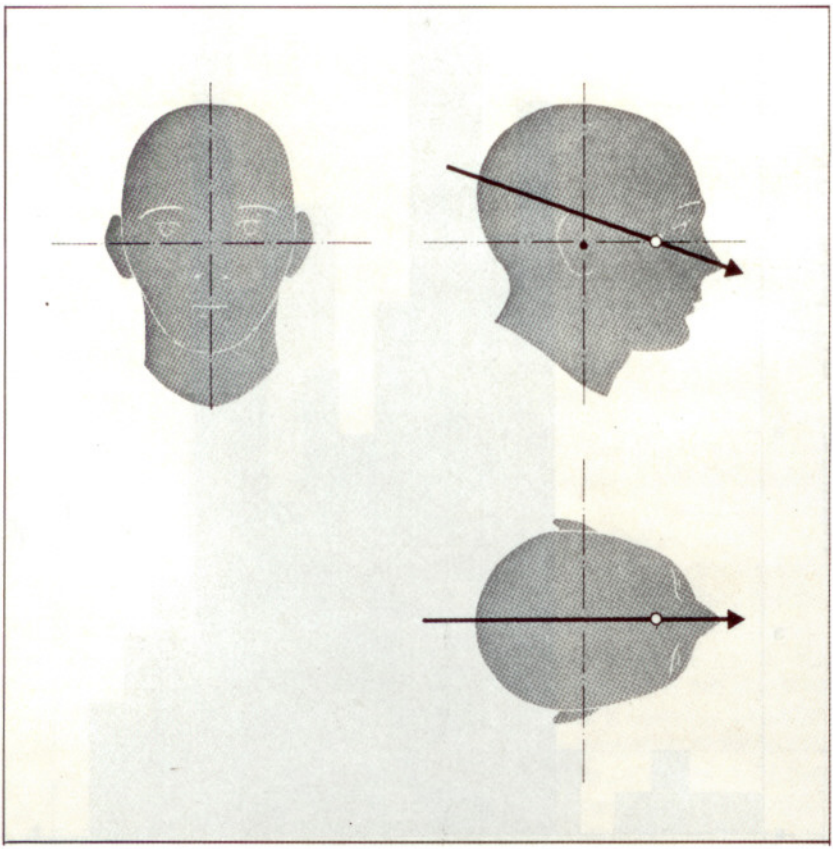

Fig. 3 The recommended beam angulation for the antero-posterior skull radiograph (By permission of Rädberg, C. and Welander, U. Maxillo-facial Radiology with Orbix).

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"ante-mortem" by comparing the size and configuration of the sinus frontalis. When a match was found the "ante-mortem" was returned to its file after the name and other details had been noted. In this way each "post-mortem" radiograph was compared with all 100 "ante-mortems".

Results

Two observers matched all 99 pairs of radiographs correctly (Table 1). One observer (RG) made one incorrect match and one patient was excluded because of uncertainty as to name and registration number of the radiographs.

Table 1. The success of three independent observers in matching radiographs

	Observer		
	RG	BE	LK
Correct ident.	98	99	99
Incorrect ident.	1	0	0

Discussion

Our study shows unequivocally that the sinus frontalis is a useful medium for identification purposes, a finding which is in agreement with that of other authors.[1,2,7,8]

Everyday medical records can be used as ante-mortem material and observers with limited training and experience can carry out the observations. In our study only one mismatch was made by one observer (Fig. 4).

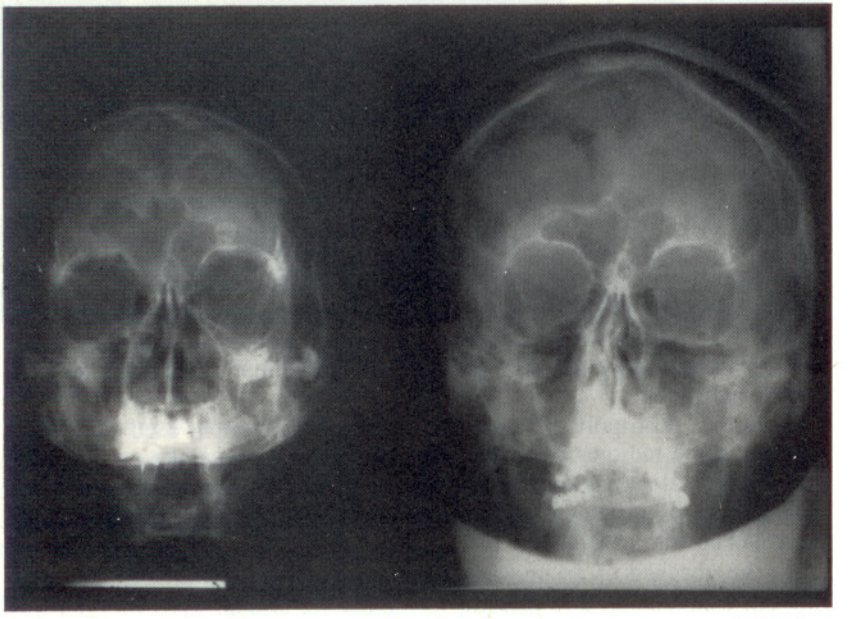

Fig. 4 Two incorrectly matched radiographs "Post-mortem" (left) and "ante-mortem" (right).

Looking closely at the two matching radiographs (Fig. 5), it can be seen that the "ante-mortem" for this patient (left) had been taken with a more caudally angulated beam while the "post-mortem" was angled nearer to the vertical, thus changing the configuration of the sinus. There were several pairs of radiographs in our material in which different angulations had been used but as the results show these projection errors hardly influenced the success of the observations. In the event of an actual identification a projection of the post-mortem radiograph similar to the ante-mortem one can usually be obtained.

Fig. 5 Matching "ante- and post-mortem" radiographs (postmortem left).

The experience of the observer in reading radiographs seems not to influence the success of the identification process. In fact in this study it was the most experienced observer (RG) who made the only mismatch. One of the observers had only the basic radiological training given in medical school on which to rely and it is envisaged that even a technician with some basic training in outlining the configuration of the frontal sinus could make a correct judgement.

Both the "post-mortem" and "ante-mortem" radiographs used were made with the same radiological equipment. In field work however even a small portable dental radiographic unit will work[9] (Fig. 6). In the event of mass disasters such equipment can easily be transported to the disaster site if electrical power is available.

In the absence of an ante-mortem radiograph at the time of the post-mortem examination it is possible to remove the frontal sinus for later use. The procedure is as follows: during the autopsy the skin and soft tissues are

Fig. 6 An example of a portable dental radiographic unit which can be used to radiograph the sinus frontalis.

dissected through the usual scalp incision down to the nose. The central part of the frontal bone is cut out with a skull saw. The defect in the frontal bone can then be filled with densely packed tissue paper or soft plaster and the soft tissues returned to their previous positions.

Later, if and when ante-mortem sinus radiographs have been found the dissected bone block can be radiographed supported by foam plastic vedges on the filmholder in order to get the desired projection.

Acknowledgements

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POSITIVE IDENTIFICATION OF VICTIMS BY COMPARISON OF ANTE-MORTEM AND POST-MORTEM DENTAL RADIOGRAPHS

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Abstract

Radiography of jaws and teeth can provide one of the most reliable sources of information for comparison between ante-mortem and post-mortem conditions leading to definitive evidence in cases of identification. Teeth and dental restorations are resistant to destruction by fire and are therefore very important in identification. The forensic odontologist utilizes dental radiographs taken of the victim before death and compares them to dental data from the remains to assist the identification. Three cases described in this paper illustrate the procedures and techniques of identification using ante-mortem and post-mortem radiographs.

Key words: dental radiographs, identification, antemortem and post-mortem comparisons.

Running Title: Identification by comparing ante- and post-mortem radiographs.

Introduction

Radiography of the jaws and teeth can provide one of the most reliable sources of information for diagnosis and evaluation of clinical treatment as well as for comparison between the ante-mortem and post-mortem conditions[1,2]. It is well established that this information can lead to definitive evidence in malpractice litigation and also in cases of identification. Similarly, radiological data can serve as convincing proof for exclusion of an individual, as occurred in the Symbionese Liberation Army shoot-out case in Los Angeles on May 17, 1974, when the post-mortem radiographical examination of the jaws of the six victims did not fit the recent dental x-ray films taken in the case of Patricia Hearst.[3]

Technical details involved in post-mortem radiological examinations have been discussed in many case reports and reviewed in forensic dentistry textbooks[1,4-9]. An increasing number of cases of individual homicide identifications as well as mass disasters have been reported, emphasizing the importance of radiological evidence. In the majority of these cases precise superimposition of ante-mortem radiographs showing details of the crown and bridge work and the presence of root fillings and different degrees of healing of extraction sockets have proved to be particularly useful information.[1,10-12]

As an illustration of how forensic dentistry provided the conclusive evidence in the identification of human remains, three cases have been selected from the files of the Department of Oral Pathology, University of Kuopio. Dental radiographs were successfully applied in the positive identification of one victim of drowning and victims of two fires.

Case Presentations

Case 1:

A substantially decomposed body was discovered floating in a lake within the Kuopio city area after melting of the ice in late April, 1989. Visual identification was unsuccessful. The body remains revealed dentate upper and lower jaws (Fig. 1) which were referred to the Department of Oral Pathology, Radiology and Forensic Dentistry, University of Kuopio, where bite-wing radiographs of the jaws were taken. Dental records and bite-wings were obtained from the local health centre of a man who had disappeared some 7 months previously. All dental characteristics found on the post-mortem

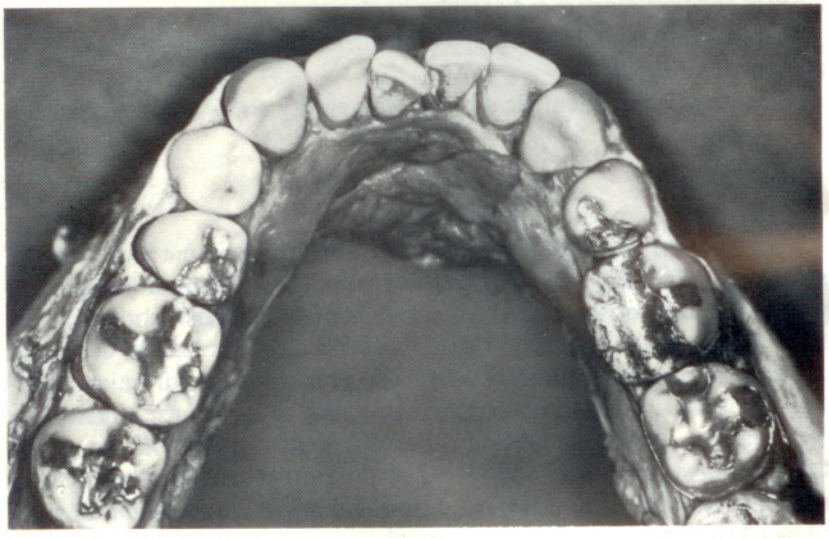

Fig 1. Post-mortem photographs of the upper and lower jaws.

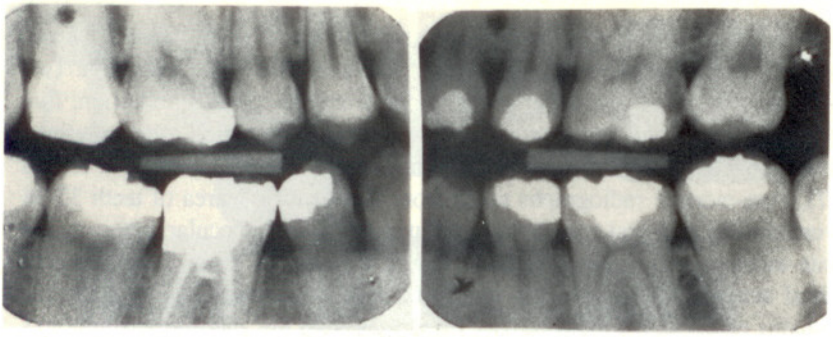

Fig. 2a. Ante-mortem bite-wing radiographs showing restorations on the molar and premolar teeth, one root filling (tooth 46) and one amputation (tooth 16). In addition, decayed surfaces are seen in teeth 27 distally, 36 mesially and 37 distally.

Fig. 2b. In the post-mortem bite-wing radiographs taken 17 months later, identical findings are seen, except that the cavities have become enlarged.

radiographs completely matched those of the ante-mortem records (Figs. 1 and 2a, 2b), thus unequivocally establishing the identity of the victim.

Case 2:

After extinguishing the fire in an uninhabited summer cottage in late 1988, a severely burned victim was found. Neither the age nor the sex of the victim could be determined by visual identification and what descriptions of the physical characteristics of the deceased were possible were forwarded to the local police concerned with identification of missing persons. Three names of possible victims were suggested. Two of these were excluded by their edentulousness while the third person had received dental treatment from a private practitioner during 1979-1983, and whose records were obtained for examination. Fortunately, the dentist had been careful in recording the dental status in 1983 but intraoral radiographs were only taken during root filling treatment of teeth 16 in 1979 and 35 in 1983. Tooth 35 was filled with amalgam using a root canal screw after the root filling.

The Department was once again asked to assist in the identification process and three fragments of the jaws were available for examination. Two of them were from the upper jaw and one from the lower. In addition, five detached roots and three crowns were enclosed of which two contained amalgam fillings and could be refitted onto the maxillary roots (teeth 16 and 17). Post-mortem radiographs taken from the lower jaw area of teeth 35-38 were similar in dental morphology, fillings and bone trabecular pattern to the ante-mortem radiograph (Fig. 3a). The root filling of tooth 35 with a root canal screw could be readily identified. The radiographs taken from the remains of the upper right molars fitted well with the ante-mortem findings (Fig. 3b) and a positive identification could be made.

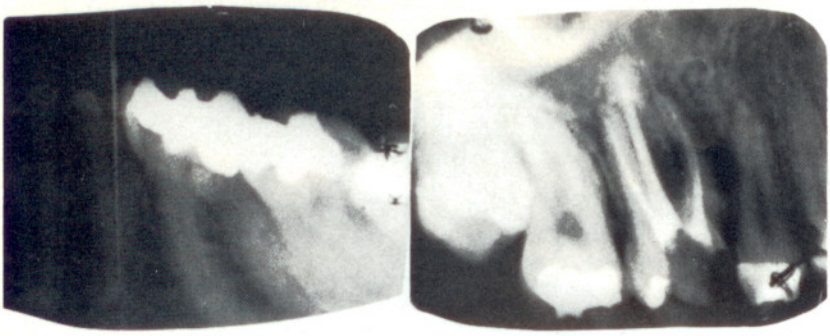

Fig. 3a. Ante-mortem intraoral radiographs showing tooth 16 after root filling (in 1979) and tooth 35 at the beginning of endodontic treatment (in 1983).

Case 3:

A charred body was pulled from the ruins of a house fire. Witnesses provided the name of the sole resident and dental records of the suspected victim were available from the Kuopio Dental School where treatment had been carried out 15 months earlier. For the post-mortem examination the lower jaw, partial lower and total upper prostheses were available. The partial denture could be fitted onto the lower jaw and in the remaining six lower teeth all six composite fillings could be identified which had been placed 15 months earlier. In addition, the dentures were identified by a local technician who had made them a few months earlier.

Discussion

Establishing the identity of deceased individuals is important in our society. Many unidentified corpses are homicide victims and it is vital to the criminal investigation that identity of the victim is known. Furthermore, a death certificate is not issued for a missing person until the body is identified or until a prescribed time and conditions expire. Pronouncement of a missing

Fig. 3b. In the post-mortem radiographs fragments of teeth 16 and 17 are seen. In addition the root filling of tooth 35 with a root canal screw is identifiable.

person as dead would only be accomplished after ten years during which time no legal procedures concerning the person could be undertaken.

Identification is of special concern to the dental profession. Dental records are the most effective means for identification of unknown bodies when decomposition, skeletonization or charring preclude visual or fingerprint identification. With most unidentified bodies there is usually a strong assumption of identity based on reports of missing persons or traceable personal effects found at the scene. It is then possible to obtain dental records of the suspected victims for use in comparison as in the three cases discussed above.

The most useful dental radiographs can be obtained after the jaws are separated and carefully placed in appropriate orientation over the dental films (Figs. 2a and 2b). The quality of the films is superior when the jaws or their remains can be radiographed by trained personnel and in a properly equipped centre. In mass disasters radiographs have sometimes to be taken in the field and in these difficult circumstances the forensic team should always include persons specially trained in oral radiology.

There are other methods that can be applied at the post-mortem stage when proper personnel and equipment are not available. The successful use

of radioactive iodine as a mobile radiation source for film exposure in mass disasters has been described.[13] Using such a small, portable intraoral radioisotope source with the film wrapped around the victim's face could be a quick supplementary aid to dental identification. In dental centres orthopantomographs have proved useful in some cases but this method would be difficult to use in the field because of the complexity of the apparatus and the positioning of the head without active co-operation on the part of the subject. Some ten years ago zonography was introduced which is a technique enabling the taking of orthopantomographs in the supine position and thus providing possibilities for application in the field.

Conclusion

Radiology has been proved to have a valuable role in identification of individual or mass disaster victims.[1,2,14]. All dentists should be meticulous in keeping complete records of their patients. Accurate demographic data should be accompanied by a record of the dental work performed and a record of the pre-treatment status of the dentition while radiographs, properly labelled, should be filed and readily accessible if required. Inadequate and unreliable antemortem data present among the greatest hindrances to identification facing forensic dentistry.

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A COMPARISON BETWEEN FINGERPRINT AND DENTAL CONCORDANT CHARACTERISTICS

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Abstract

Twelve concordant characteristics are used in fingerprint identification. The South African courts of law are prepared to accept 7 concordant characteristics as being "beyond reasonable doubt" in the case of finger, hand and foot prints. In cases of identification by dental means, 12 concordant features have been advocated. In South Africa, with its mixed population in which a large majority have dental formulae containing normal decayed and missing teeth, these patterns show duplication and triplication. It is feasible to submit 7 concordant dental characteristics as positive identification in a mouth containing dental restorations, but in a mouth which features only missing teeth, pattern duplication demands more than 12 concordant characteristics for positive identification. Seven concordant dental characteristics have not been tested in the South African courts to date.

Key words: fingerprints, dental features, concordance, identification

Introduction

The fingerprint and dental methods of identification are the most specific and hence the most scientific ways of identification applicable to the human body.[1] From the many views expressed in the literature however, it is apparent that there is no universally accepted standard for establishing fingerprint identity and a range of from 6 to 16 characteristics is found, with 12 as a consensus.[2] In the case of fingerprints the South African courts of law accept 7 concordant features as being sufficient for positive identification.[3] At present there is no minimum number of points of concordance accepted to make a positive *dental identification*. While 12 concordant features are considered the minimum requirement for dental identification by Keiser-Nielsen,[4] it has generally been found that this number of features could not always be established. One or more extraordinary features could be involved and these should be accorded their appropriate degree of importance. (Keiser-Nielsen considers an extraordinary feature as one which does not occur in more than 10% of the population). One extraordinary feature may be sufficient, in certain circumstances, to make a positive identification.

The purpose of this paper is to examine critically the need for a minimum number of concordant points in dental identification and to relate it to fingerprint identification in South Africa.

Discussion

The human hand displays approximately 100 characteristics per fingerprint and varies from 75 to 140. This makes a total of 750 to 1400 characteristics for 10 fingers. The possibility of these characteristics being duplicated are one in 1,152 x 10^{108} which is practically an incomprehensible number.[5] If only one fingerprint is used then the chance of duplication is less than one in 64 billion. The world population at present is estimated at approximately 5 billion and with millions of fingerprints on record, of which many thousands have been compared, no duplication, even in twins, has been found. This indicates that the fingerprint method of identification is at present infallible.

If one uses the human dentition for identification a different set of parameters has to be taken into account. There is a maximum of 32 teeth in a normal adult dentition. There is in a mouth of 32 teeth a maximum of 601080390 possible combinations of 16 missing teeth[4] (most people currently only have 28 teeth due to the extraction of 3rd molars). A factor to be taken into account when dealing with the population of the Western Cape region of South Africa, for example, is that a large majority has central and lateral maxillary incisors extracted or has carious loss of the first permanent molars. This reduces the number of teeth in the mouth still further to 24. The maximum number of combinations of 12 teeth missing out of 24 is thus 2704156 which is below the total population of the Cape Province. Identification by missing teeth alone must therefore be disregarded in this population group. A small percentage of the negroid population group of the Cape has dental restorative work and most dental identification attempts in this population group fail due to a lack of ante-mortem dental data. In a study by Fellingham *et al.*[6] three samples of the population of the Western Cape were examined as to the possibility of dental identification using the patterns of normal missing, decayed and filled teeth. They expressed doubt as to the possibility of identification of 4,5% of this population group where duplication and triplication was found. In their study they calculated that there are 1,8 x 10^{19} possible combinations of 32 teeth being either normal, decayed, missing or filled and there is a total of 160 tooth surfaces which may contain dental restorative materials. If one calculates the number of possible combinations of surfaces and patterns that can contain dental restorations, it then becomes apparent that duplication of these features is highly unlikely. In a study by Phillips[7] it was shown that the patterns of the amalgam restorations in molar teeth, individually or in combination, have a significant measure of uniqueness and that 3 or more amalgam restoration patterns would be significantly unique to obtain a positive identification. Despite the limitation that there is a maximum of 31 simple patterns in which teeth are restored, this would produce a possible number per mouth of 32 x 31 = 992 patterns. The probability of duplication of this number of patterns is remote.

The submission of dental evidence to the South African courts of law is a relatively new event. Seven concordant identification characteristics have been accepted by the courts for fingerprint identification and because this figure is a tried and tested one, it has become applicable to dental identification. Keiser-Nielsen[4] recommends 12 concordant characteristics for identification when dealing with the human dentition where there are no extraordinary features. It is the opinion of the author (V.M.P.) that the

circumstances in which dental identification is required usually involve a limited number of people and the identification of these people is restricted to recognition within that small group. For example, in an aeroplane crash there is a finite number of victims which would then allow a latitude of less than 12 concordant features. In the case of identification of an unknown individual or the victim of a mass disaster, this demands at least 12 concordant features per victim as one must work within the parameters of the entire population. In the event of known victims of a small accident needing to be identified it is a matter of distinguishing each victim in that group. In this case one or two distinctive features per victim would be sufficient for identification.

Seven concordant dental characteristics have not been tested in the South African courts of law and it would be prudent for a forensic dentist who submits only seven concordant points to ensure that there are several extraordinary characteristics within those 7 features.

Conclusion

In the case of a mouth containing numerous restorations, the variety of restorative patterns would make it feasible to accept 7 or less concordant features for identification as is accepted with fingerprints. However, a mouth containing a combination of normal, missing and decayed teeth, has a greater probability of duplication in our population and 12 concordant features may not be sufficient to make a positive identification. The submission of 7 concordant dental characteristics has not been tested in the South African law courts and therefore may be discarded as insufficient proof of identification when dealing with the South African population or the individual who has minimal dental restorative work.

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