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Contents

Studies of the Method of Matching Skulls with Photographic Portraits Using Landmarks and Measurements of the Dentition

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Abstract

A method of matching and identifying skulls to family snapshots or passport photographs is described. The technique depends on the recovery of teeth, particularly the maxillary anterior teeth with the skull, and on the availability of an antemortem photograph showing those teeth. The method recently used in several cases in Hong Kong overcomes some of the difficulties of previous attempts at superimposition by using selected landmarks of dental remains to compare with visible, in-focus features in photographs of suspected victims, and by establishing an accurate magnification factor from measurements of the dentition before the matching process is begun. Superimposition of these dental landmarks leads to correlation of further cranial reference points, thus enabling a successful positive identification. The application and testing of the method by the examination of photographs and dental models of a sample of Chinese students is discussed.

Introduction

The use of photographic superimposition in the identification of human skeletal remains is not new. Positive identifications established in this way have until recently, however, been viewed with suspicion not only by the courts of law, but by forensic workers themselves. Scepticism arose because of the empiricism introduced by enlarging antemortem portraits to match the size of a skull when there was no object of known size in the focal plane of the camera lens at the time the photograph was taken. This problem can now be overcome if portraits or snapshots of the victims that show their maxillary anterior teeth are available. In a recent article, my co-workers and I described how photographic superimposition was used to establish the positive identifications of three victims in a case referred to by the media in Hong Kong as the "Jar Murders".[1] In that article, we indicated how an accurate superimposition could be obtained if an antemortem smiling photograph is enlarged using a measurement from the dentition of the skull as a magnification factor, and if the skull is placed in an attitude similar to that of the head in the antemortem photograph. It was noted that further research aimed at establishing the uniqueness of the individual dentition was required

to improve the method and its value in the eyes of those who remain sceptical.

As the research project was getting underway, assistance was requested by authorities in Hong Kong in the identification of yet another victim of murder, and the victims of a drowning tragedy in the South China Sea when their ship sunk during a typhoon. In these cases the only antemortem records of any value were passport-type photographs. Thus, it became imperative to re-evaluate and refine the technique of photographic superimposition to deal with these new cases that required personal identification.

It was then appreciated that, in addition to the already enumerated requirements for accurate superimposition, a third basic problem had to be faced, that of obtaining smiling photographs of the victims. In those cases where such photographs were not available, photographic superimposition had to be attempted by the far less reliable method of "best-fit".

Evaluation

In courts of law, the scientific value of evidence presented by expert witnesses must be known. Because of the experiences gained from these cases in Hong Kong, the results of dental investigations into individual identity are now evaluated by the members of the forensic odontological team, and placed into one of the following six categories based on agreed levels of certainty:

1. Unequivocal identification.
2. Definitive exclusion.
3. Highly probable identification.
4. Consistent with, but equivocal.
5. Inconsistent with.
6. Impossible to identify.

Category 1 is an unequivocal identification based on a precise correlation between one or several unique features which are recorded in the antemortem data and which match exactly the postmortem findings. In a recent case a skull was removed from a body recovered from the sunken ship. The only useful antemortem information available for the suspected victim was a profile-view photograph. Composite tracings of the hard- and soft-tissue outlines were produced and superimposed (Figure 1). Sixteen points of correspondence in the profiles, margins and angles of the dentition were noted, and a good relationship of the soft to hard tissue was obtained. These were considered more than sufficient to justify the identification in this category.

Category 2 is an unequivocal exclusion based on one or several unique features of the postmortem findings which, when compared with the antemortem data, establishes a biological impossibility. A comparison of these data may show a large restoration in a tooth antemortem becoming two smaller ones postmortem, or a tooth marked as missing in the antemortem data apparently regrown in the postmortem state.

Category 3 is reserved for cases in which there is an agreement between antemortem and postmortem photographs by superimposition

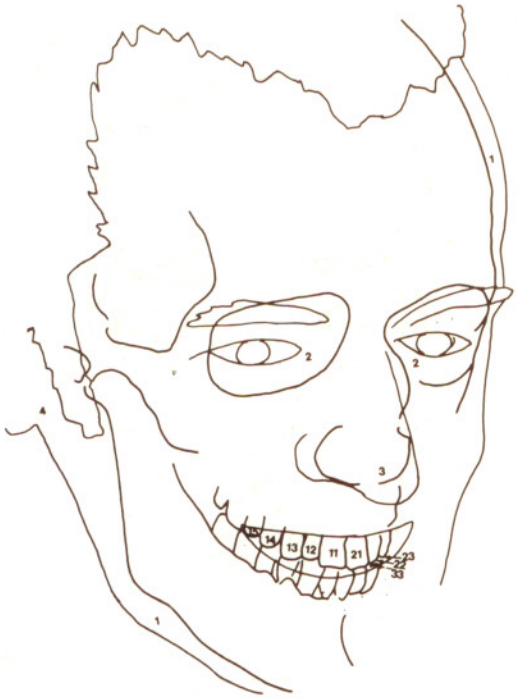

Fig. 1. Category 1: Positive identification. In this case, sixteen points of correspondence between the shapes, margins, and angles of labelled teeth could be established. (The FDI two-digit system of tooth notation is used). The correlation of soft to hard tissues is indicated by the Nos. 1-4.

or by other dental data, but where the number of exactly similar points are too few, or where there are no unique features which would otherwise make a positive identification possible. A passport photograph of a suspected victim from the drowning tragedy in the South China Sea showed a diastema between the maxillary central incisors. When this area of the photograph was examined under a dissecting microscope, a mesiodens could be discerned. In the skull the socket of a mesiodens was present, but the odontome had been lost post-mortem. If the mesiodens had been readily apparent in both skull and photograph, it is likely that superimposition would have resulted in this victim being reclassified to Category 1. The final superimposition is shown in Figure 2.

In Category 4 are found "best-fit" matches. The identifications placed in this category are equivocal because although the superimposition technique produces a "match", there are no reliable unique features, measurable landmarks, recorded data, or reported information that permit either a definitive identification or a definitive exclusion. This is undoubtedly the most contentious category. For a higher level of identification by dental means alone there must be demonstrable unique features recorded in the antemortem data which will correlate with the

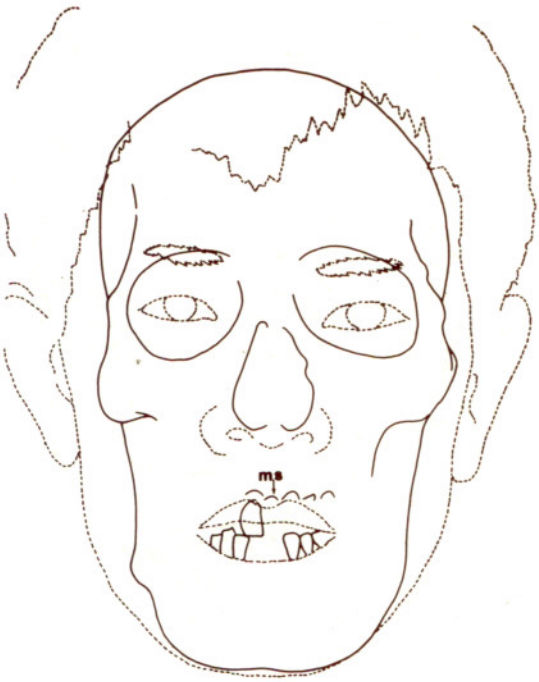

Fig. 2. Category 3: Highly probable identification. The dotted lines indicate the soft tissues and the mesiodens socket (M.S.) is shown.

postmortem findings. A recorded extraction of a tooth in an otherwise fully dentate mouth that corresponded to the postmortem assessment of the degree of repair of the socket, for example, may not be sufficiently unique to allow upgrading to a higher category. Documentation and personal effects, together with the recorded tooth loss may assist in such an upgrading, but this would require a consensus of opinions of the investigators. Figure 3 shows the composite tracings of a photograph and a skull of another victim from the ship. There were no landmarks of the dentition that could be measured and used as a magnification factor for the enlargement of the photograph to life-size. Therefore, the tracings show the best fit obtained between one of the skulls and the photograph of one of the thirty-five Chinese crew members known to have been on board the stricken ship.

Category 5 is reserved for cases in which there exists an obvious mismatch between the proportions of the facial skeleton and the face that cannot be explained by changes which might have occurred between the time of death and the time the antemortem photograph was taken. Such a mismatch is pictured in McKenna *et al.* (p. 794 Figure 4).[1]

Lastly, Category 6: "Impossible to identify" because of too little antemortem data. In such cases, there is an inability to match a skull to any of the antemortem photographs, and in order to further examine such a case more antemortem data is required. In lieu of such data, a

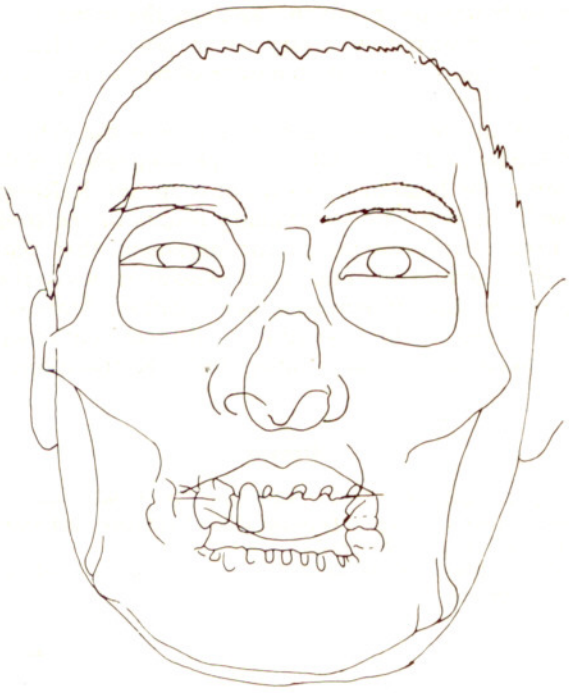

Fig. 3. Category 4: Best-fit match. The soft-tissue relationship to the zygomatic buttresses and mandibular angles is not convincing. Further photography of the skull over a wider range of angulations would have been necessary if a magnification factor could have been measured from the dentition.

much longer investigation, involving the retaking of the skull photographs over a wide range of angular positions, would be necessary.

Discussion

One of the important issues to be resolved concerns the number of points of correspondence from features of the dentition that are necessary to establish a positive identification. The validity of fingerprints in personal identification has been confirmed for many years. The numerical chance of identical prints being found is so remote that it has led to the acceptance by authorities of their uniqueness in personal identification. Most countries have established in law, a minimum number of corresponding points necessary for positive identification by dactyloscopy. For example, the U.K. considers that sixteen is the required minimum number but the U.S.A. will accept twelve.[2] Until the uniqueness of a single human dentition is demonstrated on such a statistically valid basis, the use of that dentition in identification will remain questionable.

A quantitative and qualitative analysis of the dentitions of young Chinese adults (dental students) is currently being undertaken to determine whether features and measurements of an individual's "visible"

dentition are truly unique. From this analysis the number of points of correspondence considered necessary for a positive identification of human skeletal remains using the technique of photographic superimposition will be established.

Improvements in the technique continue with the refinement of a skull holder design to allow skulls to be photographed in the attitude and angulation of the head in a portrait or snapshot. Refinement of the technique itself, coupled with preliminary results of the study of individual dentitions, lends weight to the argument that photographic superimposition based on landmarks and measurements of the dentition can have a positive value in personal identification. Authorities worldwide should be urged to allow passport- and identification-type photographs to be taken of a smiling, rather than the traditionally somber subject.

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Computer Aided Dental Identification: Experience from the Oil Rig "Alexander L. Kielland" Disaster

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Summary

In accidents involving many victims, manual comparison of dental *ante mortem* and *post mortem* data will be time-consuming. To comply with the demand for rapid identification, computers which accelerate the comparison procedure have been taken into use. The Norwegian Identification Commission has adopted a text retrieval program NOVA*STATUS for this purpose in which a file of *post mortem* information is established. From this file a specific restoration or set of restorations from the data of missing persons can be searched for. Following the identification of retrieved victims after the capsizing of the oil rig "Alexander L. Kielland" in 1980, thirty-six persons were unaccounted for. It was expected that many of those were entrapped in the rig which was righted and searched again in 1983. Prior to this operation, *ante mortem* dental information of the missing persons was filed in the computer like an ordinary missing persons file used by the police. Only six bodies were found who were all identified. In computer-aided identification, a critical selection of the data to be given to the computer is important. Accurate proof reading of the data filled is also necessary. Finally, searching for restorations of the premolar/molar regions is preferable as these are usually documented radiographically.

Introduction

Identification of large number of deceased victims of disasters by comparison of *ante mortem* and *post mortem* dental information is time consuming. In order to reduce the time required for these procedures, computers may be used. A number of systems and programs have been proposed.[1,2,3] The Norwegian Identification Commission has adopted a text retrieval system, NOVA*STATUS for this purpose.[4] An opportunity to test this system was provided following the uprighting of the capsized oil rig "Alexander L. Kielland" in 1983 and the subsequent recovery of a number of victims of this disaster. Details about the disaster and the dental identification of the immediately found victims have been reported previously.[5,6]

NOVA*STATUS

The NOVA*STATUS is based on the British STATUS ONE program.[4] As input, all dental information concerning each deceased victim is

termed a *document* which is subdivided into *sentences.* A *sentence* comprises the description of a single tooth. The text retrieval program enables the user to locate all documents containing a specific *word* or combination cf words within a sentence. The full text of a retrieved document can be displayed for examination and manual comparison. As an example, this sentence, 45 MOADCA, consists of six words: 45, M,O,A,D and CA; informing that amalgam restorations are placed in the mesial and occlusal surfaces of the lower right second premolar and that there is a caries lesion in the distal surface of the same tooth. In NOVA*STATUS terminology, each word may consist of numbers, multiple or single letters and is separated by space. Usually, a file of *post mortem* information is established, and this file can be searched for a specific restoration or set of restorations corresponding with the data of the missing person.

"Alexander L. Kielland" and Ante Mortem Information

Following the identification of the 87 victims recovered after "Alexander L. Kielland" capsize in 1980, thirty-six persons were still reported missing. It was expected that many of those were entrapped in the rig which was subsequently towed to Stavanger, Norway, and the Norwegian Government decided that the oil rig should be righted. As a result of a carefully planned operation, the platform was returned to an upright position during July-August 1983. In spite of a thorough search of the rig, only six bodies were found. Of course, identification of the six bodies, or even the thirty-six if all should have been found, could be carried out without the aid of a computer. In order to test the NOVA*STATUS system in a real accident, it was, however, decided to computerize the search and identification procedures.

Prior to the uprighting operation of the rig, all dental *ante mortem* information concerning the missing persons was collected and entered into a Honywell-Bull computer. This necessitated a minor modification of the original system where the *post mortem* data is filed. Generally, the *ante mortem* information is based on written record from dentists and on radiographs of the missing person. In the present *ante mortem* material, approximately ⅓ of the records were without any radiographs[7] (Table 1). In 26% of the records, bite-wings were the only X-rays enclosed. Bite-wing with supplementary periapical exposures were avail-

Table 1: Radiographic documentation accompanying the dental records

	%
None	31
Bite-wings only	26
Bite-wings and supplementary periapical exposures	26
Periapical exposures only	17
Full survey	0

(From: Dahl, J. E. and Solheim T. (1984): Tannlegejournaler innhentet ved "Alexander L. Kielland" ulykken. *Nor. Dent. J.*, **94**, 13-15.)

able in another 26%, and in the remaining 17% of the records, a few pariapical exposures were found. No full mouth radiographic survey had been performed. Usually, it is very difficult to obtain dental records from all the dentists whom a deceased has visited during his or her lifetime. Thus, *ante mortem* information is usually less detailed than the *post mortem* data.

Applications of the Computer System

Search in an *ante mortem* computer file for a specific *post mortem* detail, say a 16 MODL restoration may lead to the following difficulties. There is no *ante mortem* information available about this tooth of the missing person in question, and there is limited *ante mortem* information recorded, as an example, only a aprt of the filling is noted in the dental record, like 16 L. In both cases, the search procedure would fail to locate the correct missing person unless certain modifications are made. The first difficulty can be managed by the use of a combined question which will expose documents with the correct information, 16 MODL, and documents with no information about 16. To avoid the slip out of documents in the case when limited information is available, it is advisable to search for teeth with one single restoration, like a crown or few simultaneously filled surfaces.

Further, information about incisors and canines is often scarce because these areas are seldom covered by radiographs. A filling in the lingual pit of the upper lateral incisor may be considered characteristic, but is usually placed at a young age and may often not be noted in records available when the patient is middle-aged. The possibility of few *ante mortem* details available makes this region less suitable for computerized comparison with *post mortem* data.

Several commonly experienced difficulties in regard to the dental records, such as an incorrectly noted tooth or surface and disagreement between the dentist and the forensic odontologist about the correct identification of a specific tooth, occurred during the identification of the victims of the "Alexander L. Kielland" disaster.

In our own experience, the following two aspects should be considered to minimize these problems: First, the written *ante mortem* records should be carefully evaluated and compared to data obtained from radiographs. Secondly, since bite-wings are most commonly available, the restorations which are most likely to be in the computer, are those placed in premolars and molars. Therefore these restorations should be used early in the searching procedure.

Our experience also revealed the necessity of accurate checking of the data filed in the computer. In the "Alexander L. Kielland" disaster, the same dentist who entered the data into the computer, also did the checking. Errors in the data were discovered, and in one case manual comparison had then to be carried out. It is therefore most important to have another person, preferably an experienced dentist, to do the checking.

In conclusion, several difficulties were encountered by using a file of

ante mortem data instead of *post mortem* data. The most striking of these was the lack of *ante mortem* information about all teeth, which, seriously impedes the searching procedure, and which may result in failure to achieve identification. The experience gained in the "Alexander L. Kielland" disaster was emphasized the importance of careful checking at every stage of the computer procedures.

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Progress in Forensic Odonto-Stomatology in the State of Michigan, U.S.A.

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Michigan law requires all Michigan law enforcement agencies to obtain and submit to the Michigan State Police the dental records of any person missing over 30 days, and requests similar submission of dental records of unidentified deceased.[1] This dental data is entered into the Michigan Law Enforcement Information Center computer (LEIN) as well as into the National Crime Information Centre computer (NCIC) of the Federal Bureau of Investigation (FBI) in Washington, D.C. The federal Missing Children's Act of 1982 now allows children's dental records to be entered into the NCIC — by the parents themselves if necessary. The computerized dental recording system was established in 1983, update in 1985 and is now on-line for over 50 000 agencies throughout the United States.[2,3] At present there are well over 9 million records in the NCIC, with about two-thirds of the missing persons records those of children.[4]

Michigan law also requires the State, each County, and all accredited hospitals to establish and annually test emergency operations plans for possible disaster or mass casualty situations.[5] In 1979 the author established, trained, and equipped four Dental Identification Teams for the State which are now an integral part of the State of Michigan Emergency Preparedness Plan. Our local Kalamazoo County plan and its Dental Identification Teams were updated in August 1984. Each team has a complete field equipment set and each team member has an identification card with colour photograph, physical data, and fingerprint issued by the Sheriff's Department, authenticated by the County Civil Defense Director and signed by the County Chief Medical Examiner.

Another Michigan law requires all Michigan dentists to make dental records "suitable for identification" and to retain those records, including radiographs, for at least ten years after the last dental treatment afforded each patient.[6]

For many years the State of Michigan has had laws requiring Michigan dentists to report to the Department of Social Services any suspected cases of child abuse.[7] While such cases have always been of interest to the forensic dentist, they have become increasingly important in view of recent statements indicating that 30 to 50 percent of such cases involve bite marks,[8] and the fact that such marks can often either pin-point the abuser or eliminate suspects.

Although it has been stated that bite mark identification work antedates both anthropometric and dactyloscopic cases,[9] the first known Michigan case in which a bite mark was the critical or the only evidence

in a criminal case was tried in 1982. This case was also unusual in that the mark was made by a complete denture.[10] There seem to be few such cases in the literature; Harvey states that he had never seen any, and a recent Canadian denture bite mark case was described as "unique".[11,12]

Michigan has had another recent case which may become of historic interest. As a Deputy Sheriff and the Forensic Odontology Consultant for the St. Joseph County of Michigan the author was requested to examine the site and evaluate the human skeletal remains discovered at an excavation. Several authorities stated presumptive provenience indicated interment had been prior to the year 1864 and prominent forensic anthropologists determined the remains to be of a Causasian male in his mid-thirties at time of death.[13]

The dental apparatus exhibited several silver amalgam restorations placed in preparations certainly more primitive in pattern and execution than those used in the United States since at least 1900. All facts place the time of insertion of these fillings in the period 1840 to 1864. This was an era in the United States when amalgam restorations were in such ill-repute that any dentist found guilty of placing them was refused membership in the then precursor of the American Dental Association. There seem to be no other examples of amalgam fillings from this period in the United States, including collections such as those of the Smithsonian Institution. The only report of a similar restoration dating from 1833 - 1848 seems to be an example from London, England.[11]

A recent possible problem area in such work has developed in Michigan and several other States. In response to American Indian and certain other ethnic groups all such recoveries from older burial sites must be reported to and cleared by the State Archaeologist before they may be studied. This situation has recently become an area of concern for those working in archaeological, anthropological and palaeopathological fields.

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Dental Identification: Some Problems and Solutions?

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All of those who have been involved in identification of the dead are aware that this is a difficult facet of forensic dentistry and, even the most experienced and clinically detached practitioner, will admit that it is also an unpleasant and distressing task that he would hope to complete as soon as possible. Bearing this in mind then, I would like to cover some of the problems related to dental identification and to suggest some possible solutions for your consideration. In my view the problems may be broadly grouped under factors related to the disaster, the victim and the profession.

The nature of the disaster is obviously beyond our control — but they often have common features and they do not always occur at convenient locations. Also by their very nature they present the forensic investigators with difficulties arising directly from their cause or aftermath e.g. fires — explosions. In addition the ever increasing volume of international air travel with its multinational passenger loads and larger aircraft, compounds the forensic problem in the crash situation and accentuates some aspects I will deal with a little later on — namely collection, interpretation and collation of dental data.

Factors related to the victim. Of particular importance here are those aspects related to age, nationality and socio-economic groupings.

The extremes of age — on the one hand you have the very young with little or nothing in the way of dental records — an ever more common situation as fluoridation makes ever increasing inroads into caries.

On the other hand there are the elderly with the full dentures — prostheses which are often destroyed, fragmented, lost or at least displaced in the violence of the disaster and which rarely have identification marks on, or in, them. Then there are countries where the dentist/patient ratio is particularly adverse and where therefore restorative procedures and radiography, two most useful tools in identification, are minimal.

Finally, there is the socio-economic status of the victim — those who have had infrequent and, regrettably, often unrecorded treatment for the relief of pain. Turning then to *factors related to the profession.* Firstly there is a lack of appreciation of the importance of forensic dentistry — probably due to the fact that forensic matters intrude very infrequently, if at all, on the professional life of the individual practitioner. Secondly, there are deficiencies that flow directly from this lack of appreciation: (a) Failure to accept forensic dentistry within the fabric of clinical dentistry as evidenced by the time taken to establish various forensic societies and (b) the failure to keep full and accurate dental records of current patients plus the alacrity with which the records of

past patients are disposed of. And finally there is a lack of formal educational training in forensic dentistry. Although this aspect is fortunately being resolved in some countries, it still remains a major problem in many others.

Let us look now at the *identification procedure.* Firstly there is the pressure applied — for political, legal or other purposes — to achieve speedy resolution. Tenerife is a good example of this. Then there is the adequacy, or otherwise, of storage facilities and the presence, or otherwise, of adequate numbers of trained professionals. The varying legal requirements play a part e.g. in New Zealand it is required that a part of the body essential to life must be present. Also there may be the lack of coordinated training and cross matched knowledge involving police, pathologists and dentists — this in turn leads to time-loss and frustration — particularly when the other pressures, already outlined, are applied.

Finally there is *the time taken in the collection,* collation and reconciliation of AM data and its subsequent marrying up with PM information so that positive identification can be made.

That concludes this rather broad brush look at the problems of identification and I would like to turn now and look at some possible solutions to these problems. On doing so I make no apology for covering some very basic topics, because I believe, experience has shown that these basic precepts are honoured more in the breach than in the observance and because I believe if we can correct these fundamental deficiencies the benefits will flow through and beyond forensic dentistry into the overall practice of our profession, something which must not only benefit us but also our profession and the community at large.

The solution to the problems I have raised and the others, which time precludes my covering here, lie largely within our hands and may be considered under three separate but interlocking headings. For the purpose of presentation I propose to deal with them as separate entities, but I would emphasise that they interlock and overflow one into the other. The three major factors are *Communication, Standardisation and Education.*

Communication. One of the main problems arising from mass disasters can be communication — in the Mt. Erebus crash the victims came from the Far East, Europe, America, Australia and the U.K. — as a result the collection of data, done by various agencies and means, proved to be a major administrative problem and we were still receiving AM records some five weeks after the requests had gone out from the DVI team. This in the day of the satellite and the micro chip, can hardly be called a satisfactory state of affairs. The solution to the problem would seem to lie in two areas:

1. A simple direct method of reaching the source of material and
2. A rapid and secure means of dispatching that material to its destination.

The answer to the first problem appears to me to be that requests should go via a law enforcement agency to a forensic dentist. Such a person knows what is required and the importance of it to the ID team.

As regards the second aspect — I have experienced with the transmis-

sion of dental data, written notes, radiographs and photos using telephotography, and whilst I would not suggest this is the ultimate answer it fulfils many of the requirements hitherto lacking, namely speed, accuracy, flexibility and security.

Standardisation. Any one who has dealt with a mass disaster will appreciate the fact that the records arrive in all shapes and forms, not only do you get every system taught around the world, but some individual practitioners have their own peculiar ideas as well.

From what can be seen of things, although there has been some standardisation of dental charting systems nomenclature, we still have several major systems and the chance of world-wide acceptance of any one system by dentistry in general, appears a remote possibility at present.

But I believe our commonality of interest and involvement should be broad enough to transcend national boundaries and individual prejudices, and that we, as an international forensic group, should adopt one system for our use and that dental information sent from, or to us, should be in that system only.

Education. Here I believe lies the nub of the solution to many our problems. Without doubt education needs to start within the profession. By this I do not envisage that all dentists should be formally educated to become forensic experts, but rather that there should be an input, starting at the undergraduate level and continuing onto the practising members of the profession, that will cause the profession to appreciate the part they all have to play in forensic dentistry.

The initial responsibility for a such programme lies primarily with the academics in the teaching schools and faculties. However I believe we also have a responsibility both as individuals, and as a group, to play our part.

Within our respective dental associations we could, and should, be a voice advocating those aspects of dentistry we know to be of particular importance in relation to the forensic sciences.

In particular we must address ourselves to the upgrading of dental records which are, after all, the corner stone on which dental identification rests. We could, and should, make the effort to publish on matters forensic, not only in specialist publications, but also in the general dental journals of our various associations.

Then there are the allied sciences — our experience has been that relationships often depend on the development of personal understanding and rapport. So when either the dentist or the policeman, or pathologist moves for one reason or another, this relationship is broken and has to be painstakingly rebuilt. I do not find such a situation satisfactory and I believe there is a good case to be made for ever increasing interprofessional education. To this end I believe we should avail ourselves of membership of allied professional groups, we should also actively encourage a reverse flow of individuals into our societies and also we should encourage group seminars and meetings with our opposite numbers in allied branches of forensic science.

In closing may I leave you with these thoughts: The identification of

the dead by dental means is a well established and respected facet of forensic sciences and it is therefore one which places on us all grave responsibilities. Whilst many of the problems we face in dental identification are beyond our control some important areas can be influenced by our actions, outlook and activities, and it is to these areas that we should turn our attention. I believe it is within our grasp to organise both national and international forensic dental communications so that we can transmit standardised dental data to DVI teams. I believe this can be done speedily, accurately and securely.

I believe our major problem lies in the fields of professional communication and education. We have a need, and a responsibility, to educate our professional colleagues in the ramifications and significance of forensic dentistry.

Forensic Odontology — The Future

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Introduction

The earliest references to the use of dentistry as a means of recognising individuals are less than salubrious and yet they must have been based upon pre-existing knowledge of the techniques involved. Gradually, throughout the centuries these and their use have become more refined. This process of refinement and its accompanying acceptance by lawyers and academics has not been easily achieved, depending upon assiduousness, perseverance and the adoption of high academic standards by the many practising forensic odontologists in various parts of the world.

The stage has now been reached when, with the expansion which is taking place and the attempts which are being made to regularise teaching, that stock must be taken of the achievements. It is not enough though to catalogue successes, for it is vitally important that whatever expansions are made, or new directions explored, those guiding them should do so from a firm academic base. Anything less than this will only bring disrepute, undoing the work which has been done, exposing new practitioners to ridicule and failing to provide society with the service which it has a right to expect.

The Scope of Practice

Specialisation is a necessary part of medical and dental practice. The broad subjects are too extensive for a single person to acquire expertise in all but a comparatively narrow band of the basic subject. Thus in dentistry we have periodontologists, prosthodontists, oral surgeons and others. Amongst these experts there are those who profess special skills in even more limited fields. They have, by virtue of special study obtained this finer degree of expertise and accordingly they may attract a disproportionate amount of more specialised work as compared with their colleagues. This is not to the disadvantage of either the community or the profession, nor does it of necessity mean that those who limit themselves to different aspects of the same topic are inferior. Thus for example, there are those whose practice involves a high number of patients who need precision attachments, whereas others spend most of their time doing more routine restorative dentistry.

The scope of practice which an individual adopts depends to no small degree upon his/her basic skills, interests and experience. It may be that

some limit is placed upon the scope of practice by custom and in a few areas of the world by legislation.

Forensic odontology is no different from other subjects in this context, and this has led to the development of two schools of thought about the nature of the practice. On the one hand there are those who believe that it is confined to the identification of individuals, age and sex assessment and allied topics. Others opine that subjects such as dental jurisprudence and the analysis of maxillo-facial injuries ought to be included within the subject.

It is sometimes fiercely argued that the limits should be rigidly defined and there are those who would like to see some form of statutory restraint placed upon the scope of forensic odontology. Arguments such as these do nothing to ensure that progression of the subject will occur.

However, it is equally facile to state that everyone should adopt the broader compass, for this will undoubtedly lead to poor workmanship and, as a consequence, a lack of respect amongst colleagues. Undoubtedly therefore, there must be tolerance for the views of others and any judgment made upon the scope of work accepted by an individual, must be made upon the quality of that endeavour. No other criterion is acceptable.

Trends in Education

There can be no doubt that, hitherto, the majority of the world's forensic odontologists have achieved whatever expertise they may profess, by working with others who have knowledge and experience. Recognisable postgraduate qualifications being a rarity. To a degree this is an uncertain process and is not in accord with the requirements of other specialities in medicine and dentistry. Whilst this does not necessarily mean, that those who have acquired acceptance in this way, are in any way inferior to their colleagues in other specialities, it does make it more difficult to recognise the expert. The courts do not have a reliable yardstick of judgement. Some have been able to project themselves as experts without ever obtaining the necessary teaching and academic qualification. Thankfully the ad-hoc nature of much of the so-called specialist training of forensic odontologists is ending, but there is little uniformity in the postgraduate education of these practitioners. Those who have already made advances in this respect have done much, but a great deal remains to be done.

Before any decision is made on what the needs of the student are, the requirements of society vis-à-vis the scope and amount of work to be done must be assessed. Moreover in making this assessment, the examiner must look at the nature and complexity of the task and contrast this with the available facilities. Sadly, in the United Kingdom at least, no one has any real idea of the size of the workload. This has inevitably led to the feeling amongst many workers that in this country, we neither know what we need, nor how we should make adequate plans for the future.

There is no doubt that this is not a unique situation, for there are

many areas in the world where the actual and the potential workload differ by a great degree of magnitude. Forensic odontologists cannot and must not suspect that lay people and professional colleagues will acquire an understanding of their art and science by osmosis. Amusing anecdotal lectures, designed as an after-dinner entertainment should be a thing of the past. The slickly presented paper which titillates an audience by presenting those cases which achieve notoriety in salacious publications may earn the speaker an ovation, but not the respect due to an academician or a scientist.

There can be no doubt that the level at which talks to groups of all kinds such as lawyers, policemen, doctors and dentists, must be instructional. They must provide the audience with the evidence that they need, to make a valid judgement of the potential value of forensic odontology. Thus, for example, they must be told what the percentage of positive identifications is actually made by dental means in a mass disaster, and why there were failures. Each presentation, if it is to achieve anything, must be scientifically based, carefully researched and, where necessary, statistically evaluated. Only in that way can the value of forensic odontology spread to those who ought to know. The reason for doing this is simple, and it is not just an academic exercise. There are many children who are victims of physical abuse, for example, and who have bite marks which, even if they are recognised, are not examined and their evidential value is therefore missed. Also there are many people in authority in various parts of the world, who remain sceptical of the value of forensic odontology.

To be able to do this, and to cope with work which may be generated, an adequate number of properly qualified people is required. Much of the case load will be simple identifications, a smaller proportion demanding the use of special techniques such as serology, histology and photography, for which laboratory and other facilities are essential. Many routine cases need little time, whereas more complex cases can be very time consuming. Thus two levels of expertise served by differing degrees of specialisation in facilities are required.

Because of the need for two levels of qualification, educational programmes will have to be geared to this need. Cost effectiveness in training means that training should be designed so that the maximum amount of information is dispensed without widespread disruption of other tasks to the widest possible audience. Moreover to avoid needless repetition it may be necessary, and it is probably advisable, to present the basic information to both groups at the same time.

A variety of courses have been organised throughout the world. By themselves these have done much to propagate knowledge. Some are excellent. The short course, lasting for about two weeks or so and repeated at intervals, probably provides the widest audience with the greatest chance of obtaining the necessary basic education. Longer courses may not necessarily provide more information and the cost to the individual may be prohibitive, thereby limiting their effectiveness. Courses of this nature, which require that the student gives a lot of time,

are not suitable for everyone, for employers may be reluctant to grant leave of absence and provide the necessary cover.

Setting up courses is costly and if they are to be self-financing, then a regular stream of students is needed. Moreover, even in a country as small as the United Kingdom, more than one centre would have to run a course if the needs of everyone are to be met.

It is conceivable that, if national forensic odontology societies fulfil their aims effectively and efficiently, they can, through the organisation of properly run workshops, meetings and short courses, provide the basic education. Many other medical and dental specialities have used this method in the past. They have been successful, combining high standards of tuition, with cost effectiveness. Supplementary to these and complementary with them, is the apprenticeship system, whereby post-graduate students are given on the job training by experienced colleagues.

There is a wide variety of ways in which assessment of candidates can be achieved. Masterships, doctorates and other postgraduate qualifications are available from most universities. It is essential that, whatever the qualification, however it may be obtained, quality control of the final product must be effected through independent channels. This applies as much to the teaching as it does to the student's work.

Postgraduate education is problematical, because of the need to provide for two levels of expertise. Added to this difficulty, there is the twin problem of geography and an unknown workload. Undergraduate education is much easier, the only requirement here being to provide all students with a basic introduction to each of the many aspects of the topic.

Research

Teaching students, whether they be undergraduates or postgraduates, has been shown to generate a number of difficulties. With proper organisation and careful thought about the content and type of courses offered, these ought to be surmountable. Education is the foundation upon which a successful service can be built, but continuing acceptability depends upon ever widening horizons. This does not necessarily mean that in this context, forensic odontology must espouse topics which rightly belong with other specialities. Rather, it means that, research aimed at answering the questions which at the present time can only be answered empirically must be undertaken. One example of this is the enigma of the pink tooth, for which no one has as yet provided a definitive, incontravertible answer as to the cause. Age estimation is an imprecise science, which, when compared with the exactness of techniques such as gas-liquid chromatography, appears to be a very blunt instrument indeed.

There are many avenues to be explored, both in the realms of pure and applied science, not all of which require the availability of sophisticated laboratory and other facilities. Keen observation and the accumulation of data can be done with minimal equipment. There is scope for a wide variety of interests, abilities and expertise. It is vitally important

that each and every forensic odontologist should undertake some research work. For this to be successful and not just a meaningless exercise, it must be co-ordinated and supervised. Before publication, and or presentation of the findings, they must be independently assessed.

Conclusions

To some extent forensic odontology lies at a watershed, being in part a victim of its successes and paradoxically, perhaps, its failure. The forensic sciences are populated by personalities, and strong characters do not easily form a comfortable cohesive unit. Conflicts of opinion are commonplace and the arguments surrounding them are not easily resolved. Therefore, if there is to be successful liaison between colleagues, tolerance and even acceptance of the right to hold an opposing view must prevail, especially when the scope of practice is being discussed. However, where a difference of opinion is based upon misinterpretation, or an inadequate examination of the facts, then it is right to dismiss it.

The profession must identify the needs in terms of the potential case load and make adequate provision to meet the need, if it is to prosper. Moreover, hasty decisions about what type of education is to be provided must be eschewed. Finally research must be undertaken if further advances are to be achieved.

Clairvoyance is an uncertain exercise, in which prognostications have an uncannily unnerving knack of proving false. There ought always to be a need for forensic odontology. The evidence suggests that that need will grow. If it is to be successfully met, then those who claim expertise, must show that they have the capacity to do so by their own academic achievement. This in its turn must be subjected to rigid quality control by independent observers.