RADIOLOGY IN FORENSIC DENTISTRY

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FORENSIC DENTISTRY is a fascinating aspect of dental science and has been shown to be an extremely reliable method of identification of human remains.

Individual dentists have gained much knowledge and expertise in many facets of forensic dentistry, such as oral autopsy procedures, bite mark interpretation and comparison radiography. Much of the knowledge gained has been self taught and although recorded in various journals and books, interested dentists, when called upon to assist in the identification of unknown human remains, are often at a loss as to how to examine a body, or even what to look for, as a part of the examination. Interpretation of the evidence gained from an examination, when compared to antemortem data, is also often bewildering to the untrained dentist.

Incorporated in this treatise is a review of the literature pertaining to the general aspects of forensic dentistry and more specifically the role of radiology in forensic dentistry.

Identification, in many instances, is based upon radiographic comparison and interpretation. In forensic dentistry special problems are encountered in radiographic technique and in the interpretation of radiographic evidence.

The writer has presented the problems associated with forensic dental radiology and has offered various solutions and suggestions in making this aspect of human identification, for the interested dentist, much easier than it otherwise may have been.
ACKNOWLEDGEMENTS

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I dedicate this treatise to my beautiful children Shannon, Jared, Brooke, Luke, Jordan and Angela, who have made my life worthwhile and have given me the inspiration to strive for better things.
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1. **INTRODUCTION**

Forensic Dentistry is a specialised branch of forensic medicine and may be described as that part of odontology which, in the interests of justice, deals with the handling and examination of dental evidence, from which a proper evaluation and presentation of dental findings can be made (Cameron and Sims, 1974 and Keiser-Nielsen, 1980).

1.1 **FIRST PRINCIPLES**

The primary intention of forensic dentistry is to identify people, either known or unknown, whether they are living or dead, by using mainly the dentition and supporting bony structures. These elements of the body show many particular characteristics in development, morphology, pathology and the results of varied dental treatment, which may occur in innumerable combinations. The calcified oral tissues reflect many conditions that have occurred throughout life, which are often permanent or show very slow change.

The examination and recording of these characteristics by the forensic dentist, aided by the judicious taking of radiographs, may provide evidence of age, sex or race of a person, and when compared with existing recorded information effect a positive identification.

Examinations often need to be carried out on remains that may be mutilated, burned or in varying stages of decomposition. The task is unpleasant, but must not be an excuse for inaccuracy in the recording of dental information. Small inaccuracies or omissions can seriously delay positive identification, especially when many bodies are being examined.
1.2 DISASTERS

Forensic dentistry is of special importance in the identification of victims of disasters, whether they be acts of God, or in fires or aircraft or other accidents. In aircraft accidents, the large number of victims who are burned, decomposed or mutilated can be overwhelming (Cottone and Standish, 1982), and the task of identifying them enormous.

In disasters where severe burning occurs, although the bodies remain essentially intact, visual identification becomes an impossibility. Identifying possessions such as clothing, purses and wallets, even jewellery, may be destroyed making forensic odontology the predominant technique in victim identification (Parker, 1983).

Dental identification is made possible because the teeth are protected in a conflagration by the cheeks and tongue; the anterior teeth may be charred to a greater or lesser degree depending on the severity of the fire.

Accidents involving mutilation or fragmentation of the victims also depend heavily on dental identification. Figure 1. outlines the importance of forensic odontology in the identification of the burned or mutilated victim of aircraft accidents.

1.3 RADIOGRAPHS

Pre-existing dental radiographs are a considerable aid to antemortem dental record charts. They not only establish definite identific-
Figure 1. Bar graph illustrating the different roles of dental identification in different types of aircraft accidents (Parker, 1983).
ation points, but may also assist in explaining apparent inconsistencies in records and may contain information not entered on the original charts.

In order to identify an individual, using postmortem radiographs, it is essential that antemortem radiographs can be traced and examined. Dental decay and periodontal disease are among the most common chronic human diseases and therefore the possibility of an individual having had a radiographic examination of his mouth at some time is very high (Whittaker, 1981).

Periapical radiographs are of greater value for identification purposes than bitewing or interproximal radiographs, as they show the roots of the teeth, which are often distinctive and not likely to undergo change. The bitewing radiograph, however, is the most commonly used for examination in dental practice and therefore often proves to be the most important factor in an identification.

Extraoral and intraoral radiographs both portray various anatomical landmarks, physical characteristics and/or disease states which can be used for forensic identification purposes, provided antemortem data is available.

Missing and unerupted teeth, fillings, caries, root canal fillings, pulp and root morphology and periapical and periodontal pathology are common features used for radiographic comparison. Comparisons often require meticulous attention to minute detail present in
dental radiographs, where bone trabeculation patterns, anatomic landmarks, bone "scars", nutrient canals, sinus outlines or osseous pathology may be the only features able to be used for identification purposes.

1.4 AIMS
The aim of this treatise is to discuss basic concepts in the science of forensic odontology and, specifically, to relate these concepts to the role of dental and cranio-facial radiology in the identification of human remains.
2. **IDENTITY**

In modern society the identity of an individual is an important factor in family, business, civil and social life. Every person has the right to an identity throughout his life and even after death.

Identity is a personal combination of features. Certain of these features are recorded throughout life to establish personal identity and also to discern between individuals in society. Two factors determine the basic need to establish the identity of an unknown body: the family of the person and the legal system of the country.

2.1 **FAMILY**

There is a diversity of customs of family, social and religious life throughout the world. The identification of a person following disappearance and subsequent death, or following an accident or disaster, relieves the anguish of family members, relatives and friends and removes from their minds doubts as to the fate of that person.

Religious beliefs determine the method of disposal of the body. Positive identification and return of the body to the family allows for customs to be observed, such that the deceased person may fulfil his "destiny".

2.2 **THE LEGAL SYSTEM**

The certification of death is a legal requirement in most Western countries. This certification is based upon the identification
of the body. The requirements of the Coroner's Court also requires identification to be established so that the cause of death can be investigated.

In cases where identification cannot be carried out and therefore death unable to be certified, serious complications may arise. These complications may include delays in fulfilling the terms of the deceased's will, in settling insurance and superannuation claims, probate, the finalisation of legal proceedings, business transactions and the right of a spouse to rearry. A statutory period must elapse in such cases, before a person can legally be recognised as dead and his affairs cleared. In Australia, this statutory period is seven years.

2.3 CONSIDERATIONS IN ESTABLISHING IDENTITY

The identification of a body is an official procedure. Data is recorded about the body and compared to information that has been collected from various sources. Positive identification is determined by the concordance of postmortem and antemortem data.

2.3.1 Collection and Recording of Postmortem Data

Postmortem physical data often provides much information as to identity, such as age, sex and race. This, together with related evidence may justify comparisons to be made with file data, that may have been gathered from missing persons investigations, families of suspected victims of accidents or disasters or from professional records from dental and medical practitioners.
Data collected at postmortem must be as comprehensive as possible. It is most important that evidence not be overlooked. Antemortem data may not be available for a considerable time following investigation; months or years may pass before a comparison can be made.

2.3.2 Collection and Recording of Antemortem Data

Personal data is often collected by authorities when people are reported missing and kept on file to be used when and if an unknown body is located. Often the data collected is used for exclusion purposes and in some cases for a positive identification.

Data should be collected as soon as possible following a report, as unfortunately, with time, physical data becomes difficult to establish or collect and therefore may not be available if needed later for comparison purposes.

Data needed for identification of large numbers of victims of accidents or disasters is collected by authorities as quickly as possible after the event. Lists are compiled of victims from aircraft accidents for example, using passenger lists. Specific information may then be collected for each person, that may be useful in establishing identity, e.g. photographs; dental records, including radiographs and study models; old dental appliances, finger prints and blood groupings.

2.4 IDENTIFICATION PROCEDURES

Many procedures are used to establish the identity of unknown remains, some being more reliable and specific than others.
Fingerprints and the dental condition provide the most scientifically reliable methods of identification (Griffiths, 1977 and Cottone and Standish, 1982).

Evidence of a circumstantial nature, such as clothing, jewellery and the contents of pockets, purses or wallets is widely relied upon for identification purposes, but in many cases may be most misleading (Keiser-Nielsen, 1980). Stevens in 1966 suggested that, where possible, evidence of two kinds should be obtained before the confirmation of the identity of a body is made.

Figure 2 shows the relative values of various methods of identification as used in thirteen civil aircraft accidents, including the influence of sex in the determination of identification.

It must be noted that one of the primary methods of identification of a body is by visual recognition by a family member or relative. Visual recognition is restricted to remains where the physical features of the body, especially facial features have not been distorted by injury or postmortem change. Keiser-Nielsen in 1980 reported that this method may often result in an incorrect identification.

Identification at this time has become a question of relying upon various characteristics of the body. These characteristics include features such as sex, race, age, body height and stature, hair and eye colour and fingerprints. Other features, such as scars,
Figure 2. The importance of different identification methods in 13 civil aircraft accidents (Stevens, Tarlton, 1966).
tattoos and physical abnormalities may also be present and provide useful clues to identity.

When identification is unable to be made from external physical characteristics, investigators rely heavily upon dental evidence.
3. HUMAN REMAINS AND PREPARATION FOR EXAMINATION

3.1 HUMAN REMAINS

The oral examination is an essential part of any forensic dental examination. The method of examination is often determined by the condition of the human remains (Luntz and Luntz, 1973, and Cottone and Standish, 1982), which varies greatly, depending upon the circumstances of death and the period of time that has elapsed since death and the discovery of the remains (Parker, 1983).

3.1.1 Rigor Mortis

Immediately following death, stiffening and rigidity of the body occurs. This becomes very obvious by two to four hours and by twelve hours, is complete. The stiffening of the muscles is such that joints become immovable. The process usually starts in the fibres of shorter muscles and therefore is particularly noticeable in the muscles of mastication and the neck (Cottone and Standish, 1982). This is particularly important to the forensic dentist, as access to the mouth cannot be gained without undue force, which may cause damage to dental structures.

Rigor mortis is particularly pronounced in fire victims, which take a characteristic "pugilistic pose" (Figure 3). The "pugilistic pose" is the result of contraction by heat (known as heat-stiffening) of the flexor muscles.

In the unburned body, rigor mortis lasts for approximately 24 hours after which the body regains some degree of flexibility.
Figure 3. Pugilistic Pose.
3.1.2 Decomposition

Decomposition of a body is dependent upon such factors as the circumstances of death, ambient temperature, humidity, light, pre-existing conditions within the body (such as sepsis), and occasionally, interference by wildlife.

Putrefaction of the body is caused by bacterial activity in which enzymes are produced to digest tissue to a fluid state. This process is characterised by the liberation of a variety of gases (e.g. carbon dioxide, ammonia and the foul-smelling hydrogen sulphide, H₂S, and methyl mercaptan, CH₃HS). These gases cause tissue distension and give the body a bloated appearance after several days (Figure 4).

Decomposition sees the skin change colour from normal to green to purple and, finally, black. The eyes and tongue bulge, the skin loosens and slips and may peel from the hands and feet like gloves or socks.

Insect invasion of the body, especially in warmer temperatures, produces maggots which eventually, with the bacterial activity, may completely decompose the soft tissue of the body (Figure 5).

3.1.3 Mummification

A process of mummification may occur in bodies that have been subjected to hot, dry climates and where there has been an absence of flies. The internal organs decay, but the skin undergoes considerable shrinkage and becomes tough and leathery and resists decomposition (Luntz and Luntz, 1973 and Cottone and Standish, 1982).
Figure 4. Putrefaction.
Figure 5. Skeletonisation.
Goldie and Bulluss, in 1985, suggested that mummification may also occur if bodies have been subjected to cool, windy conditions, as may be found in river flats.

3.1.4 Skeletonisation

The end product of decomposition of the soft tissue is skeletonisation. The skeletonised body is usually dry, has no odour and, from the forensic point of view, is the most pleasant of cases on which to work. The skull is easily detached from the rest of the skeleton and the mandible may be disarticulated at the temporo-mandibular joint for examination.

3.2 ACCESS TO THE ORAL CAVITY FOR EXAMINATION

The condition of the head of unknown human remains at the time of postmortem examination, will determine the procedure employed by the forensic dentist, in gaining access to the oral cavity, for the purposes of photographing, charting and radiographing the dentition.

The head of the unknown human remains at the time of examination can be generally described as being one of the following:

(i) in normal condition
(ii) burned
(iii) mutilated
(iv) partially decomposed
(v) skeletonised.

In some cases (e.g. air disasters), there may be a combination of conditions existing in one head, such as mutilation and burning.
3.2.1 Head in Normal Condition

Forensic dental examination of a body in normal condition is usually carried out when the victim is unknown and no clues to identity such as personal belongings have been found with the body and when there is no record of finger prints (Figure 6).

Prior to examination of the oral cavity, potentially identifying features are photographed and accurately recorded. Once the rigidity of rigor mortis has passed, the mouth can be relatively easily opened with a Ferguson mouth prop. The dental examination is then proceeded with, using a mirror and probe, as in the living patient.

As visual identification of the body may be possible at a later date, the same care should be taken as with a living person. Under no circumstances should the facial features be disturbed or incisions made to gain access to the oral cavity (Luntz and Luntz, 1973, Stimson, 1977, and Goldie and Bulluss, 1985).

3.2.2 The Burned Head

The effect of burning on a body depends on many factors; the heat, proximity and duration of the flames and often the incendiary material (Harvey, 1976).

In severe fires, the top of the skull usually burns first, then the brain, followed by the mouth. Gas in the intestines, stomach and lungs often causes the tongue to protrude and swell, thereby
Figure 6. The visually identifiable body.
protecting the teeth; however, anterior teeth may be charred (Figure 7). If the victim has died before the fire engulfs him, the oral cavity may remain essentially intact, even if limbs are burned off.

The victims of fire are probably the most difficult upon which to perform a dental examination because of the problems associated with gaining access to the oral cavity (Keiser-Nielsen, 1963, and Salley, Filipowicz and Karnitschnig, 1963).

It is not unusual for the tissues to be fused together; the mouth, nose and eyes may be non-existent and the tissue hard, crusted and unyielding.

In cases of superficial burning (Figure 8), it may be possible to perform a dental examination as in the intact body, as access to the mouth is not difficult (Harvey, 1976 and Pert, 1980).

In cases involving moderate and severe burning, visual identification is usually not possible. Access to the oral cavity is therefore accomplished by performing an oral autopsy. If large numbers of victims are to be identified, resection of the jaws may be carried out to facilitate examination (Keiser-Nielsen, 1963, Salley, Filipowicz and Karnitschnig, 1963, Luntz and Luntz, 1973, Harvey, 1976 and Goldie and Bulluss, 1985).
Figure 7. The burned head, protruding tongue  
(Courtesy, Dr. C. Griffiths).
Figure 8  Superficial burning

(Courtesy, Dr. C. Griffiths).
Utmost care must be exercised when handling the dental tissues of severely burned victims, as parts or even all of the dentition may have carbonised as a result of the intense heat of the fire (Figures 9 and 10). In such cases, the affected teeth may crumble during the course of the examination.

3.2.3 The Mutilated Head

Mutilation is always the result of violent injury, as may be associated with high speed motor vehicle accidents, plane crashes or physical assault. The skull may be shattered and the facial tissues torn and fragmented, leaving the victim beyond recognition.

The facial skeleton, as with other parts of the body, may be strewn over a large area. Teeth may have been avulsed or fractured and may be found remote from the victim or deep within body tissues or organs (e.g. trachea or lungs). In such cases as many fragments of facial skeleton and teeth as possible should be recovered from the accident site to be used in the subsequent dental examination and identification procedures.

Petersen and Kogon in 1971 described their experiences examining victims of the Woodbridge Air Disaster, which involved the tedious and painstaking task of recovering teeth and dental fragments, dissecting remaining fragments free from mutilated victims and charting each specimen. Antemortem charts were then compared with each fragment in turn.
Figure 9. Carbonised teeth.
Figure 10. Carbonised teeth
(Keiser-Nielsen, 1980).
So far as possible in examinations involving few victims, recovered dental fragments and teeth should be positioned in their correct anatomical relationship to each other (Figure 11). This enables maxillary and mandibular structures to be recorded, photographed and radiographed more easily (Luntz and Luntz, 1973).

3.2.4 The Partially Decomposed Head

The partially decomposed body is often repulsive to see and offensive to smell. For these reasons, dental examination of these bodies is most unpleasant.

The partially decomposed body found on land is often infested with maggots (Figure 12), may be bloated and almost black in colour. The facial features are usually unrecognisable.

Bodies recovered from water are often more grotesque than those from the land (Figure 13). Water temperature plays a great part in the rate of decomposition, the greater the temperature then the greater the rate of decomposition (Harvey, 1976).

Within a matter of eight to ten days, the skin becomes sodden and may be peeled off in strips. The hair becomes loose and finger and toe-nails come out easily. In a matter of weeks, the flesh breaks down to slime and falls from the body. Marine life may destroy facial features and severely damage the body within two or three days.
Figure 11. Specimen from mutilated head

(Courtesy, Dr. C. Griffiths).
Figure 12. Partially decomposed head.
Figure 13. Body recovered from water.
In very cool water, the soft tissues of the body undergo hydrolysis and hydrogenation of oily body oleic acid into hard stearic acid. This condition is known as adipocere, the tissue resembling greyish-white soap (Figure 14). Following this process, the surface features of the body may be preserved for years.

Access to the mouth in the majority of cases of partial decomposition is made easier by performing an oral autopsy and/or removing the jaws for examination.

3.2.5 The Skeletonised Head

The completely decomposed or skeletonised head is the easiest to work on so far as dental examination is concerned. There is usually no disagreeable odour and access to the mouth is not a problem. The skull is easily detached from the rest of the skeleton and the mandible from the base of the skull (Figure 15).

The teeth of the skeletonised head may be brittle and loose. In some cases, anterior or conical shaped teeth may be easily lost from the alveolar processes and may fracture if they fall onto hard surfaces. Care must therefore be taken when handling these specimens.
Figure 14. Adipocere

(Courtesy, Goldie and Bulluss, 1985).
Figure 15. Skeletonised head

(Cameron and Sims, 1974).
3.3 THE ORAL AUTOPSY

The exposure of the dentition for unobstructed examination and recording often depends upon the mobility of the mandible, as determined by the amount and texture of the remaining facial soft tissues. Several methods of exposure have been devised and will be described. In each case, it must be noted that the facial soft tissues should be disfigured as little as possible.

3.3.1 The "Horseshoe-Shaped" Incision Technique

The "horseshoe" or "U-shaped" incision technique for exposure of the dentition was recommended by Jakobsen, Keiser-Nielsen, and Tolderlund in 1974, and is now widely used. The technique provides ready access to all the teeth and all surfaces.

A "horseshoe-shaped" incision is made approximately 2-3cm below the mandibular base, following it from one angle to the other (Figure 16). A second incision under the tissue surface is made on the buccal aspect of the mandible into the sulcus, freeing the buccal soft tissues. Distally, the masseter muscle is severed at the mandibular base.

The tissue flap thus mobilised, representing the chin and lower parts of the cheeks can then be turned inside out and drawn over the face to completely expose the buccal surfaces of both mandibular and maxillary teeth.

If the jaws are to be resected for examination, the flap may be
Figure 16.  "Horseshoe-shaped" incision
(after Jakobsen, Keiser-Nielsen
and Tolderlund, 1974).
further mobilised and drawn upwards to the level of the lower orbital margins, by placing an incision through the upper buccal sulcus.

After examination or jaw resection, the tissue is able to be repositioned and sutured, leaving little change in facial expression.

3.2.2 The "V-Shaped" Incision Technique

The "V-shaped" incision technique is used extensively to expose the dentition of severely burned bodies and has been described by Luntz and Luntz in 1973 and Vale and Noguchi in 1977, (Figure 17).

An inverted "V" incision is made on each side of the face from the commissure of the mouth, to the angle of the mandible and to the base of the ear. The wedge of tissue thus formed can be folded back to expose the oral cavity for examination or to enable the jaws to be resected.

3.3.3 The Rectangular Incision Technique

This oral autopsy technique enables the dentition to be examined with minimal effort (Keiser-Nielsen, 1963 and Cottone and Standish, 1982).

This technique is characterised by the removal of a rectangular section of the cheeks, including the lips, to the base of the sulci (Figure 18). In this way, the buccal surfaces of the dentition are exposed for examination.
Figure 17. Inverted "V" incision
(after Luntz and Luntz, 1973).
Figure 18. Rectangular incision
(after Cottone and Standish, 1982).
In each autopsy technique, the tissues of the floor of the mouth need to be incised to enable the mobilisation and/or resection of the mandible.

3.4 RESECTION OF THE JAWS

The removal of the jaws often provides a distinct advantage for the forensic dentist, when many examinations are to be made. Removal enables supplementary photography, radiography and examinations to be undertaken more easily and often in better clinical surroundings (Luntz and Luntz, 1973 and Keiser-Nielsen, 1980).

Once the jaws have been exposed, as described above, the mandible may be removed by either disarticulation or by resection.

Disarticulation preserves the structures of the mandibular condyle and coronoid process. The soft tissues are dissected to temporomandibular joints and ligamental structures severed enabling the mandible to be removed.

Resection of the mandible can be performed much more quickly, by cutting through the ramus with a reciprocating autopsy saw.

The maxilla may be removed in one piece, by making a horizontal cut with the autopsy saw, at a level well above the nasal spine and apices of the canines. The cut is continued distally just above the level of the floor of the maxillary sinus on each side. The maxilla is then mobilised downwards with the aid of a large
skull chisel. It may then be removed by dissecting free the palatal soft tissues and ligaments along its posterior border.

3.5 MACERATION

Specimens to be retained are macerated. Soft tissue is firstly scraped away as much as possible from the jaws which are then boiled for 48-72 hours in a fluid detergent solution. Any remaining soft tissue may then be lightly scrubbed away with a nail brush. The jaws are bleached in a 5% hydrogen peroxide solution for approximately eight hours, washed in hot running water for two hours and allowed to dry (Figure 19).
Figure 19. Clean, dry specimen
(Keiser-Nielsen, 1980).
4. THE POSTMORTEM RECORD

The purpose of the postmortem dental examination is to accurately record potentially identifying characteristics within the oral cavity of the unknown body (Luntz and Luntz, 1973).

The need for accuracy and completeness in the examination is important, as the significance of a recorded observation may not become apparent for some time after the investigation, or even until after the remains have been disposed of (Sopher, 1976 and Parker, 1983).

4.1 IDENTIFICATION FORMS

The information obtained from the dental examination is recorded on a postmortem identification form, to be compared at a later time with available antemortem dental charts. The form should not be complex and should include adequate space to depict the morphology of dental structures and restorations.

Interpol has developed a Disaster Victim Identification form (Figure 20), which has gained wide acceptance. This form is used both in the recording of data of victims of mass disasters and also in the individual case of unknown remains.

The basis of this form is an odontogram upon which characteristics are recorded diagrammatically, using the PDI notation.

4.2 METHOD OF RECORDING

Under ideal conditions, the dental examination should be undertaken
### Victim Identification Form

(Approved by the International Criminal Police Organization—Interpol)

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Specific description of crowns, bridges and dentures

Further findings (Occlusions, attrition, anomalies, staining, calculus, periodontitis, etc.)

Radiographic examination of

Supplementary examination

Age evaluation (Method)

---

**Figure 20. Victim identification form**

(Interpol).
by two people, one performing the examination and one recording the data. Two people functioning as a team provide cleaner and more accurate records than the single-handed operator (Keiser-Nielsen, 1963 and Sopher, 1976).

Two investigators reduce the likelihood of recording errors, as a double-check approach is used. Each piece of information obtained is verified and if a disagreement occurs, both opinions may be recorded and resolved later, when details are compared to the ante-mortem data (Brannon, 1983).

According to the circumstances of the examination being performed, additional postmortem evidence such as radiographs, photographs and study models may be obtained to corroborate information recorded on the postmortem odontogram and for comparison with ante-mortem records.

4.3 THE EXAMINATION

The postmortem examination and charting is a meticulous and time-consuming procedure. Careful note of the condition of the remains is recorded, including the degree of decomposition and, if present, burning and/or mutilation.

In cases of facial mutilation, the soft tissues are examined for dental fragments which, if found, are labelled and examined in detail later.
Intraorally, the soft tissues are examined for any indications of trauma, discolouration, burning or surgical scarring. The condition of the gingival tissues including pigmentation and oral hygiene status of the victim are also recorded.

All characteristics of the dentition may then be charted. These will include not only restorations of the teeth, but also such features as missing teeth, prosthetic replacements, jaw relationships (Class I, II or III malocclusions), diastemas, tooth alignments, tori and any other unusual aspects.

### 4.4 CHARACTERISTIC FEATURES

A brief review of important dental characteristics will be discussed below:-

#### 4.4.1 Dentures

If dentures are present, the information that may be of assistance in the identification of the victim may include the material of the denture base (acrylic, chrome cobalt or gold); the mould, shade and material of the teeth (porcelain or acrylic); the number of teeth; pseudo-restorations (gold inlays or crowns); special characteristics, repairs and alterations such as the shape of the palatal relief, the shape and depth of the seal and, in some cases, a technician's job number and/or patient's name.

Complete dentures of themselves may not be of value in helping to establish the identity of an unknown body. Not infrequently,
the individual has been edentulous for many years and no identifying marks or features may be incorporated in the denture (Haines, 1973, Mertz, 1977 and Brannon, 1983).

4.4.2 The Teeth
The body being examined may possess teeth or none at all. The teeth present may be entirely natural, artificial or a combination of natural and artificial.

The basic procedure is to chart the standing dentition in the normal manner. Each tooth present must be correctly identified and then recorded. The absence of any teeth from the mouth must be investigated (including the use of radiographs) to ascertain whether they had been extracted antemortem; are unerupted and/or impacted; or, in cases where the bodies are in various stages of decomposition or may have had a traumatic injury, whether missing teeth were lost at the time of death or at some later time.

Any unusual features of the teeth, such as staining or discolouration, attrition, erosion, abrasion or enamel hypoplasia should also be recorded, as combinations of these features may be quite distinctive.

4.4.2.1 Tooth sockets
The postmortem loss of teeth is not infrequent and results from the deterioration of the periodontal ligaments. Tooth loss is often found in decomposed bodies, especially those submerged in
water and almost always to some degree in skeletal remains. The anterior teeth, having a conical root shape, are usually involved, as these teeth fall out or become easily dislodged by movement (Sopher, 1976).

In non-decomposed remains, the socket of a tooth lost postmortem, will be free of blood clot and will not show any evidence of gingival bruising as the result of vital haemorrhage. In the recently deceased, a clot observed within a tooth socket implies recent antemortem tooth loss.

Postmortem tooth loss in skeletal remains will be seen as a smooth socket wall, with a sharp alveolar rim. In contrast, recent or old antemortem tooth loss will show varying degrees of bone remodelling.

4.4.2.2 Dental caries
Dental caries should be described by tooth surface. Carious areas in the dentition may lead to undermining of the enamel and subsequent fracture (Griffiths, 1977). Such fractures are most common in the molar teeth and are characterised by an irregular surface. Traumatic fractures, however, are most frequently seen in anterior teeth and often extend into sound dentine. The fracture line is sharply demarcated.

4.4.2.3 Restorations
Dental restorations should be carefully recorded, noting the size,
shape and tooth surfaces involved, as well as the restorative material used.

For the body subjected to fire, intense heat may cause the enamel caps of the teeth to separate completely from the dentine. In these cases it is still usually possible to determine the extent of the restoration from the shape of the cavity base in the dentine (Parker, 1983).

Crown or bridgework when encountered, should be carefully described. This should include designation of the abutment teeth and pontic sections, including the type of metal framework used, the facing material, shade and any other distinctive features.

Anterior synthetic restorations may often be difficult to detect. In these cases, a magnifying glass may be used. Midda in 1969 and Keiser-Nielsen in 1980, however, suggested that a disclosing solution be used to detect anterior restorations. The solution concentrates along the margins of the filling, making it stand out.

When restorations may have been lost, any remaining base or cavity lining should be recorded. Missing amalgam restorations may often be deduced by the characteristic greyish staining of the dentine.

4.4.2.4 Occlusion, and anomalies of shape and number

Particular attention must be paid to the accurate recording of
developmental anomalies, such as congenitally absent or supernumerary teeth and unusual tooth morphology, such as peg-shaped or Hutchinson's incisors (Luntz and Luntz, 1973, Sopher, 1976 and Parker, 1983). These features may be of great significance, as they are most likely to have been recorded previously and may be apparent in antemortem photographs.

Similarly unusual features of the victim's occlusion should be described, especially severe Angle's Class II or Class III relationships; as well as any segmental crossbites and unusual displacements or rotations of individual teeth (Cameron and Sims, 1974 and Sopher, 1976).

4.4.3 Oral Pathology

Deviation from the normal anatomy of the oral cavity applies not only to the teeth, but also the soft tissues (including the tongue) and bony structures. Depending upon the observed pathology, certain conditions of the oral cavity may impart varying degrees of specificity to an individual, according to the percentage incidence in a population group (Griffiths, 1977).

Oral conditions that are specific include: palatal and mandibular tori; common tongue abnormalities such as geographic tongue, black hairy tongue and macroglossia; Dilantin induced hyperplasia of the gingivae; the linear pitted defects in the enamel of anterior teeth related to febrile illness during childhood and possibly pre-existing bony pathology, such as cysts (Sopher, 1976 and Cottone and Standish, 1982).
4.5 SUPPLEMENTARY INVESTIGATIONS

The postmortem odontogram is the basis for dental identification. The forensic dentist however, on many occasions must supplement this chart with other records, in the interests of accuracy and for comparison purposes, to complete the postmortem investigation.

4.5.1 Photography

Postmortem photographs are taken essentially for reasons of documentation of the case, and as an adjunct to the written record.

Photographic recording includes a general view of the head, with close up views of the front, side views and occlusal views of the exposed dentition.

Photographs reflect in great detail the position and alignment of individual teeth; differences in colour; the detailed outline of restorations; the gingival level and soft tissue pigmentation as well as other features, that would be difficult to otherwise describe (Figure 21).

Features of particular interest are photographed separately: for example, full and partial dentures, crown and bridgework and also occlusal anomalies, etc.

4.5.2 Radiography

Radiographs are the most important supplement to the clinical postmortem dental examination. They constitute an objective form of
Figure 21. Photography of the dentition.
registration and contribute a multitude of details that cannot be recorded by any other means. The radiographic examination therefore, should be carried out to its fullest extent. This is important as there is always the chance that, at some stage during the investigation of the identity of unknown remains, antemortem radiographs may be presented for comparison.

Few mortuaries have portable X-ray facilities available. For this reason it may be necessary as part of the examination of an unknown body, to remove and macerate the jaws. Radiography can then be performed under ideal conditions on clean, dry specimens.

A suggested radiographic survey on an unknown body would be :-

( i) Upper anterior periapical views
(ii) Right and left bitewing views
(iii) Right and left oblique lateral views of the mandible.

These films are most likely to contain identifying features, that may be compared subsequently with antemortem records, when and if these become available.

Radiographic dental identification techniques will be discussed in detail, in subsequent chapters of this treatise.

4.5.3 Dental Models

Models of the dentition are desirable in cases where the jaws may not be removed from the body. They provide a three-dimensional
reproduction of the dentition, to which reference can be made at any later time. Models gain additional importance when kept as a stable reproduction of provisionally reconstructed, fragmented jaws. They may also preserve the full view of a dentition, from which individual teeth or partial dentures, etc. have been removed for specific examination.

4.5.4 Age Assessment

Age assessment from the dentition is an aspect of forensic dentistry that is recognised as one of the most reliable methods for the determination of the age of human remains (Parker, 1983).

Dental age is determined by references to the stages of development of the deciduous and permanent dentition and the changes which occur to them throughout life. It is an attempt at realisation of the chronologic age of the victim (Cottone and Standish, 1982).

Luntz and Luntz, (1973), suggest as a general guideline for age determination and in the absence of sophisticated scientific equipment or expertise, the following indicators:

(i) Extensive wear on teeth is usually not present under the age of 50 years;

(ii) Excessive bone loss usually does not occur under the age of 40 years;

(iii) Closure of the 3rd molar apex usually does not occur before the age of 20 years;
(iv) For estimating age of children under 14 years, dental development charts may be used.

A detailed examination of the radiological assessment of dental age will be discussed in a subsequent chapter of this treatise.
5. ANTEMORTEM RECORDS

The identification or exclusion of unknown human remains by dental means, requires that antemortem dental information be available for the forensic dentist to compare with the postmortem record. Commonly, antemortem records are not available at the time an investigation has been requested and for this reason, the postmortem examination should be as comprehensive as possible.

To minimise delays and to aid the investigation the forensic dentist must be provided with the most complete and detailed dental information that can be obtained. Particular emphasis is placed upon antemortem radiographs (Harvey, 1976, Vale and Noguchi, 1977 and Griffiths, 1977).

Unfortunately, many dentists consider that charting a patient's dentition is a costly procedure so far as time is concerned and it is frequently looked upon as being non-productive (Knudson and Cottone, 1984). Mertz in 1977 suggested that many dentists may rely upon radiographs as a means of recording previous dental treatment. All too often the only antemortem dental information that may be available may be a cryptic reference to item numbers and the fees charged.

5.1 COLLECTION OF DENTAL INFORMATION

The search for antemortem dental information should begin early in an investigation, as some material may be difficult to locate and may take considerable time to arrive (Vale and Noguchi, 1977).
In Australia, the police routinely collect available information from dentists, hospitals, institutions, the armed forces and other sources, as may be provided by relatives and friends of the deceased.

Instructions are given to collect such information as dental record charts, clinical photographs and study models, from orthodontists and prosthodontists; old prosthetic appliances, mouth guards and removable orthodontic appliances, financial ledger sheets and family photographs (Sopher, 1976). All have relevance in establishing identity.

In the ideal situation, the forensic dentist will contact the deceased person’s dentist and request relevant information; when the information is collected by the police, the forwarding dentist may be assured of :-

(a) confidentiality of records;
(b) the involvement of legal, non-interested parties;
(c) dentist to dentist contact;
(d) the importance of keeping accurate records and forensic awareness;
(e) the return of relevant information upon completion of the investigation (Parker, 1983).

Information sought from overseas, especially in case of air disasters, may present difficulties as bureaucracy may complicate the collection of dental records. Parker in 1983 suggested that such information may be more easily obtained by contacting a recognised
forensic odontologist from the particular country in question, or the national dental association of that country or the police force. This can usually be undertaken by Interpol.

5.2 DENTAL DATA

The data of prime interest to the forensic dentist in establishing identity is:

( i) the written dental record;
( ii) dental radiographs;
( iii) dental models;
( iv) recollections of the dentist, family or acquaintances.

5.2.1 Dental Records

Dental records maintained by dental surgeons, usually contain a diagramatic chart or odontogram outlining tooth surfaces and detailing treatment completed and/or to be done, with a written description of the treatment given, including fee charged. Rarely is the pre-existing dental status of the patient recorded.

Dental treatment charts in use today are available in many sizes, shapes and formats. A patient's record may comprise different chart types and information recorded may be in any one of over forty tooth numbering systems and symbols in common usage today (Harvey, 1976, Sopher, 1976). This may cause confusion and difficulty in interpretation by the forensic dentist. Inaccuracies or omission in recording treatment may also cause confusion.
Treatment charts maintained by public hospitals, institutions or the military forces often provide clinical information of a comprehensive nature, including pre-existing dental status, details of occlusal relationships and records of treatment required and given.

Treatment charts, regardless of their inadequacies, the numbering systems or notations used, are the main source of information for the forensic dentist and are therefore invaluable in helping to establish identity.

5.2.2 Radiographs
Keiser-Nielsen, Johanson and Solheim in 1981 stated "that the value of a radiograph in identification is always positive, even if it is not technically perfect." This is especially true in cases where the ante-mortem dental chart is inadequate (Sopher, 1976).

Antemortem radiographs of any type, no matter how old they may be, need to be obtained wherever possible. Radiographs provide such information as the presence of impacted and unerupted teeth; crown and root morphology; the delineation of specific morphology of restorations; the degree of alveolar bone loss; apical calcifications and bony healing in extraction sites, as well as the results of extended treatment in cases such as endodontic treatment or prior jaw fractures, which may show evidence of wires or other fixation devices (Knudson and Cottone, 1984). Anatomical features such as sinus configurations, foramina, condylar morphology, mandib-
ular canal morphology and bony trabecular patterns all provide specific information that often permit positive identification to be made (Sopher, 1976, Mertz, 1977 and Knudson and Cottone, 1984), when compared with postmortem radiographs.

Positive measures such as full dental charting and intraoral radiographs have been instituted by bodies in various countries for persons at risk, as was suggested by Humble in 1953: e.g. the Royal Australian Airforce, for aircrew and the Scandanavian Civil Aviation Boards, where as a condition of service, aircrew must have a series of fourteen intraoral radiographs taken, to be filed by the employing company in the "health bags" for ready access in case of accident (Keiser-Nielsen, Johanson and Solheim, 1981).

5.2.3 Dental Models

Dental models, which are exact replicas of the patient's dentition are not usually retained by the dentist or dental technician, unless for specific reasons, such as orthodontic treatment, unusual tooth relationships or arrangements or interesting prosthetic or surgical problems. When models are retained, they are invaluable for comparison with postmortem remains (Furness, 1976, Sopher, 1976 and Knudson and Cottone, 1984), and, as such, should be specifically requested by investigators.

Koelmeyer et al, in 1983, reported the identification of unknown remains, by the comparison of study casts made from the full upper denture, found with the remains and from two sets of old dentures kept by the assumed victim's wife.
Prosthetic prescription forms, detailing the construction of fixed or removable appliances, may also provide clues to identity in cases where a dental appliance is found with unknown remains (Knudson and Cottone, 1984).

5.2.4 Recollection of the Dentition

Cases occasionally arise where dental records may have been destroyed, or family members may not have been aware of the deceased person's dentist (Sopher, 1976). In such cases, even though there may be numerous points of dental specificity, positive identification may not be made (Griffiths, 1977).

Gustafson in 1966, Sopher in 1976 and Vale and Noguchi in 1977 recommended that useful information may be derived from careful discussions with the deceased's dentist, family and friends. Dentists are often able to remember unusual dental features or specific restorations (Gustafson, 1966), whilst family members and friends may recall characteristics such as a chipped tooth, a diastema, missing teeth or a protrusion (Vale and Noguchi, 1977).

Family photographs may hold vital clues that may help to establish identity (Furness, 1976, Sopher, 1976 and Parker, 1983), especially if there are characteristic features of the anterior teeth. Furness (1976) and Koelmeyer et al (1983) mention photographic superimposition over the skull of a victim as a valid means of establishing identity.

In the collection of antemortem dental records, it is important to gather the most recent records, regarding treatment given to a
patient. This applies to cases where the deceased may have received care from several dentists. Where earlier records of treatment only are available, irresolvable inconsistencies and incompatibilities may hamper the investigation because of alterations resulting from subsequent work.

5.3 REARRANGEMENT OF ANTEMORTEM DATA

Written dental records often contain information irrelevant to a forensic investigation. Conservative treatment of a single tooth over a period of time may mask or completely remove evidence of previous treatment. The forensic dentist must reduce the record to that data which depicts the latest known state of the dentition. This is achieved by beginning with the latest entry and working backwards, disregarding irrelevant notations.

Many dental practitioners use personal abbreviations and symbols, in their recording of dental treatment. If this notation is not readily understandable by the forensic dentist, he must then consult with the practitioner for clarification (Keiser-Nielsen, 1980). Apparent contradictions in the charting, such as impacted teeth being wrongly recorded as missing, or molars and premolars being incorrectly designated, where previous extractions have taken place, must also be clarified (Furness, 1976 and Griffiths, 1977).

The forensic dentist on occasions, may have to rewrite a record, entry by entry, such that all information is presented in an understandable and correct form. Once accomplished, all relevant data
is transposed onto a form similar to that used for the postmortem record (Mertz, 1977, Keiser-Nielsen, 1980, Morlang, 1982 and Gwale, 1982), including information that may have been derived from antemortem radiographs, study models or clinical photographs, for comparison (Figure 22).

Sopher in 1976 stated:

"... from the standpoint of antemortem information, effectual dental identification necessitates:

1. a suspected identity of the unknown body or bodies in question, and

2. the availability of recent and accurate antemortem data for comparison."

In considering the latter specification, Griffiths in 1977 indicated,

"the failure to record accurate and complete antemortem dental records is often responsible for the inability to identify remains which contain numerous dental characteristics. The characteristics cannot be checked because of the poor or inaccurate records maintained by the attending dentists."

The completeness of the antemortem record often depends upon the amount of time, effort and energy that the investigators are willing to devote. Extra effort may produce that one record, radiograph or photograph that may make the identification easier, if not positive.
Figure 22. Antemortem dental identification form

(Courtesy, Dr. C. Griffiths)