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DENTAL IDENTIFICATION IN

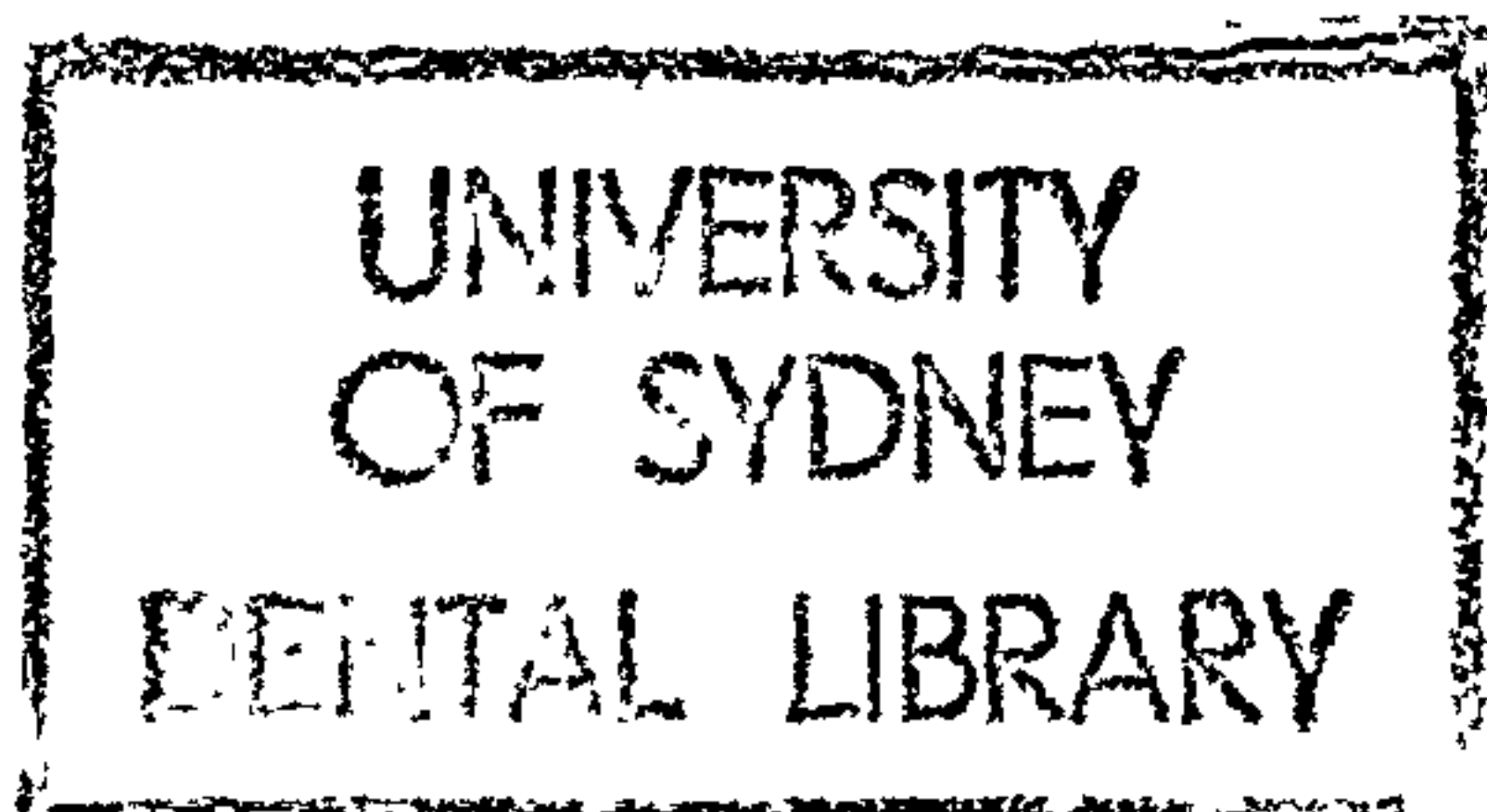
MASS DISASTERS

by

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A dissertation submitted in partial
fulfilment of the requirement for a
Diploma of Public Health Dentistry
in the University of Sydney

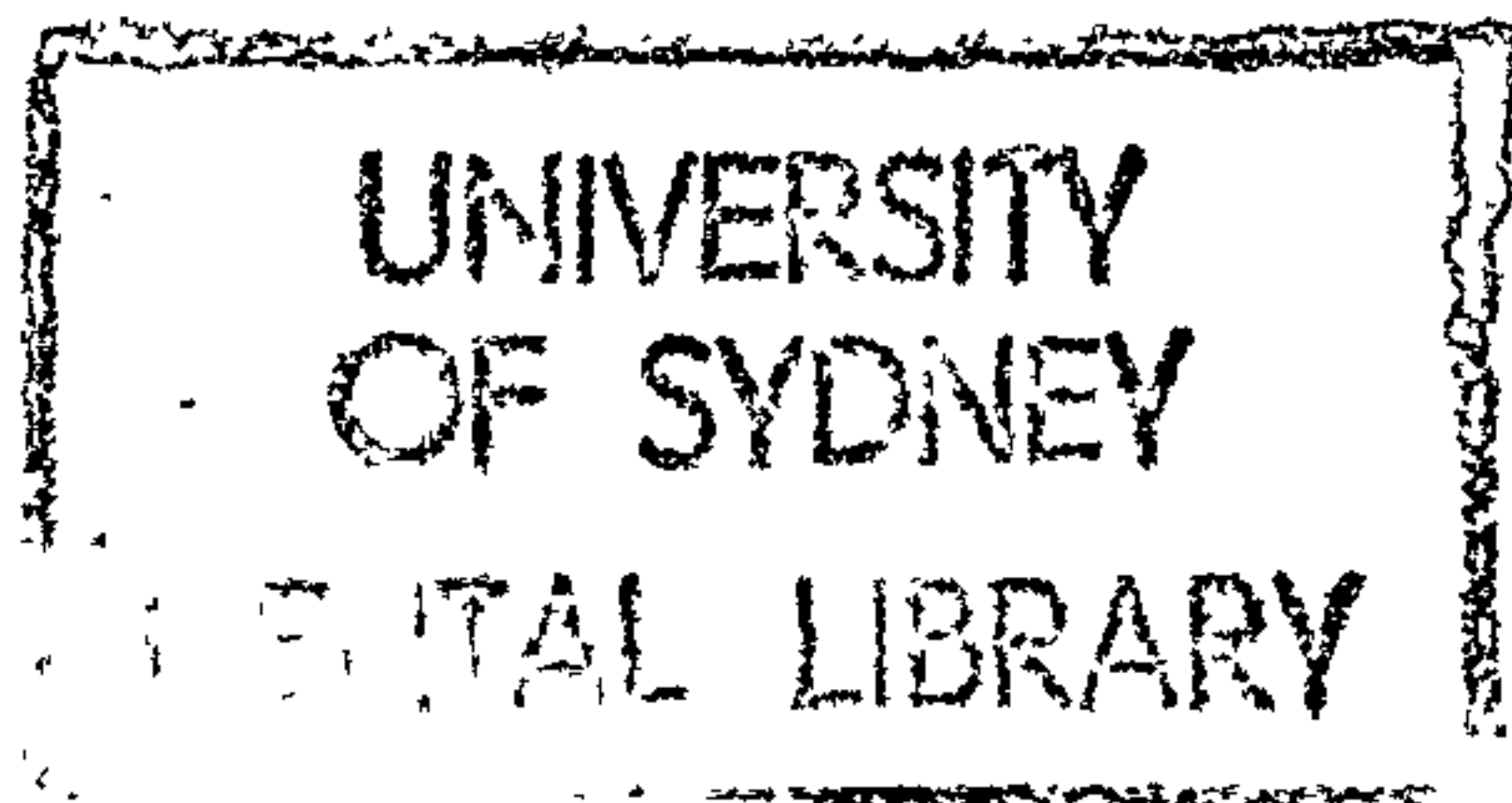


December, 1977

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I. BASIC CONCEPTS

Human teeth and their supporting jaws show many particular characteristics in development, morphology and pathology. The oral structures reflect many conditions which have occurred throughout life. These conditions are often permanent, or show very slow post-mortem changes.

Over the last five years there has been a great increase in published material relating to forensic odontology. This has been largely due to the increase in demand for the expertise of the forensic dentist in the identification of persons killed in aviation accidents.

The primary focus of forensic odontology is upon the identification of an unknown body by using the dentition. In this field the dentist has worked in close cooperation with law enforcement agencies, the forensic laboratory scientist, the coroner, the lawyer and the forensic pathologist. It follows, that forensic odontologists must not only have accurate knowledge of world-wide current dental procedure, but also be aware of current police and Coroner's Court procedures. Similarly, it is important for the police, pathologists and the legal profession to have a basic knowledge of the services which can be provided by the forensic odontologist.

Forensic odontology can be defined as "that branch of dentistry which, in the interests of law, deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of such evidence".³¹ The professional expert is a specialist who places his particular professional expertise at the disposal of those requesting his assistance, but leaves the legal conclusions that may be drawn from his results to the requesting authority. His main obligation is to point out facts, but he may also be called on to make professional judgments on the basis of these facts. Where dental evidence is concerned, the establishment of simple facts is within the capability of the dental general practitioner, however evaluation of these facts usually requires further expertise usually held by a forensic dental expert.

The examination of corpses is often made more unpleasant by the advanced decomposition, or by the smell of burnt body tissue. This however is not an excuse for inaccuracy in recording of the dental condition, even small inaccuracies or omissions can seriously hamper identification, especially in mass disaster situations. In criminal cases, the person who carries out the examination of the body and submits the report is the person called to give evidence at a trial or inquiry and so may be cross-examined on his findings.

In the past surgeons gained their knowledge from personal experience and a few published case reports. Now a greater proportion of dental schools are establishing both chairs and lecturships in forensic odontology. The Armed Forces Institute of Pathology at the Walter Reed Army Medical Centre in Washington DC offers an annual four day course to one hundred dental participants. The Federation Dentaire Internationale (FDI) Subcommittee on Forensic Odontology has world-wide contacts with forensic dentists and has collected information and references to establish an international library on the subject. The FDI also has a good liaison with Interpol and is seeking to gain support for the adoption of a universally acceptable system for dental charting.

2. METHODS OF IDENTIFICATION

It is asked why we bother to try to identify persons after mass disasters, the rationale behind this line of questioning is that the victims are dead, so we cannot help them in any way. This argument against time consuming identification is valid, until the interests of the next of kin are taken into consideration.

Identification of the body is necessary so that a death certificate can be issued. This certification of death is necessary to finalize legal procedures such as insurance, wills, business transactions, remarriage of a spouse and lawsuits involving any negligence.

The religious beliefs of the victim and his relations have a strong bearing on disposal of the body. The Chinese and Japanese strongly request the identification and return of any of their nationals who have been killed in an aircraft accident. Most orientals are extremely loath to have their relatives buried in mass graves; they like to have some part of the body returned. Many South East Asian races practice ancestor worship.

The establishment of identity, following the disappearance and subsequent death of a person, at least ends the anguish of the unknown fate of a 'loved one'.

In New South Wales (N.S.W.) alone, there are over 5,000 missing persons reported each year. The majority of these missing persons are young people under the age of sixteen. Every time there is an unidentified corpse found all the parents of these missing children suffer the anguish of not knowing if it was their child who had died. Society has a great obligation in identification of the corpses; to relieve all but one of these parent groups. The identification of missing persons has strong political connotations in the United States (US) where there has been much agitation for the recovery and identification of the bodies of American military personnel declared missing in action during the South Vietnam war. The identification of a body affords great relief to many families who have missing sons - at least the families are not left with the doubt that an unclaimed body may have been their son.

In modern society the most important reason for identification is to permit the issue of a death certificate. In many countries such as Sweden and Denmark, if there is no positive identification of a missing person presumed dead, a death certificate cannot be issued until three years later. In some States in the United States of America and in Australia the length of time before issuing a death certificate may be up to seven years. During this time, the spouse cannot remarry nor can probate be granted.

It is most important that all bodies in major aircraft disasters be positively identified. In the Turkish Airlines Disaster near Orly Airport, where three hundred and seventy four persons died, one hundred and thirteen passengers were not positively identified. If this percentage of non-identification of victims becomes the norm and the situation becomes public knowledge, then it will not be long before someone makes criminal use of this non-identification of all victims. A person could take out an extremely heavy insurance policy on his life, pay another person to take a trip on an airline under the first person's name and then sabotage the aircraft thereby killing up to 400 innocent victims, and do a 'stonehouse' and try to collect the life insurance when not actually dead.

Methods of Identification of the Dead

Various methods are used in the establishment of the identity of unknown remains, some are more reliable and specific than others. Personal characteristics such as finger prints and the dental condition are the most specific evidence; circumstantial evidence such as clothing and personal property is less satisfactory and can, in many cases, be most misleading. Serrens⁽⁶⁵⁾ suggests that wherever possible, evidence of two kinds should be sought before the identity of a body is confirmed.

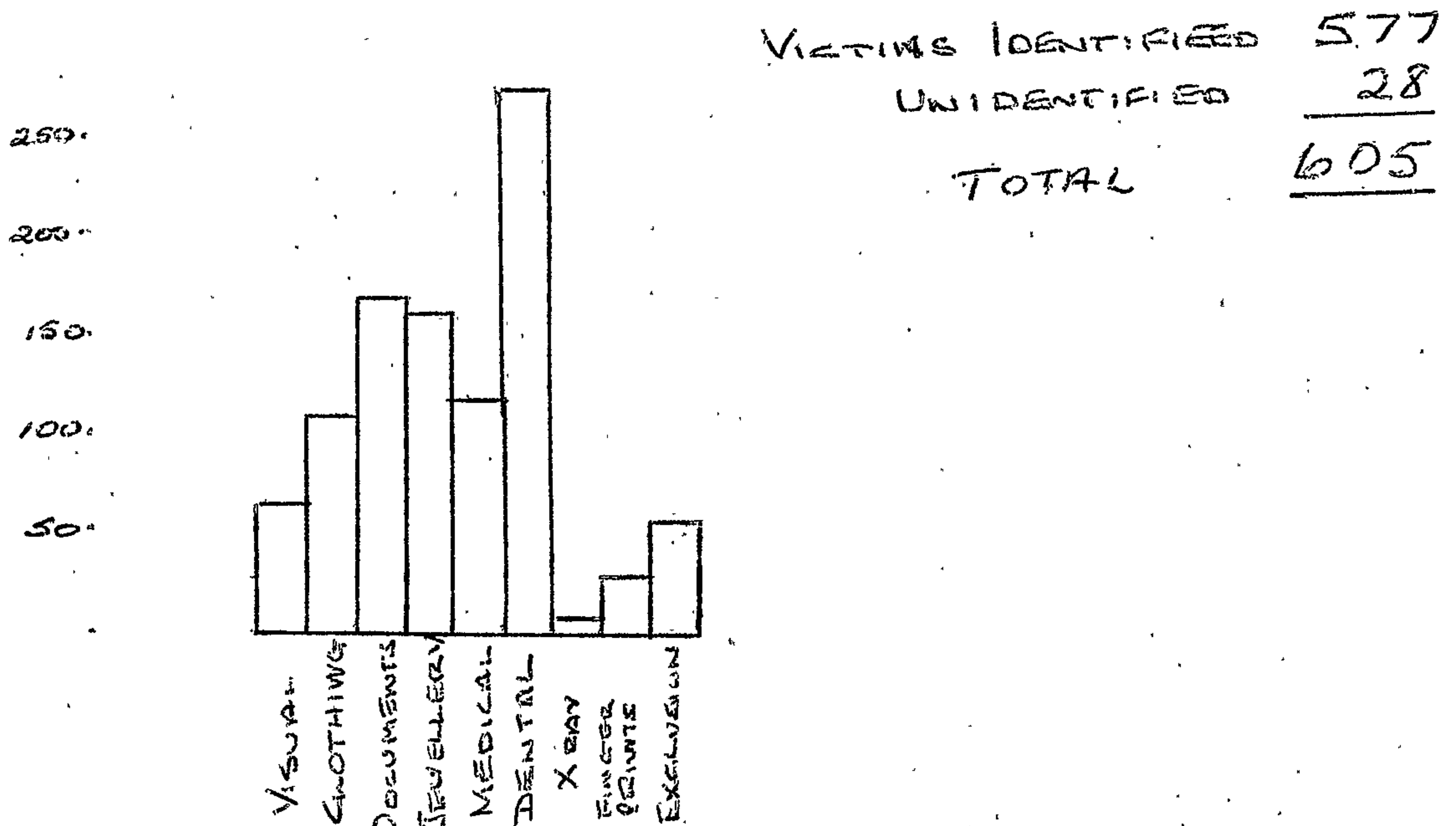
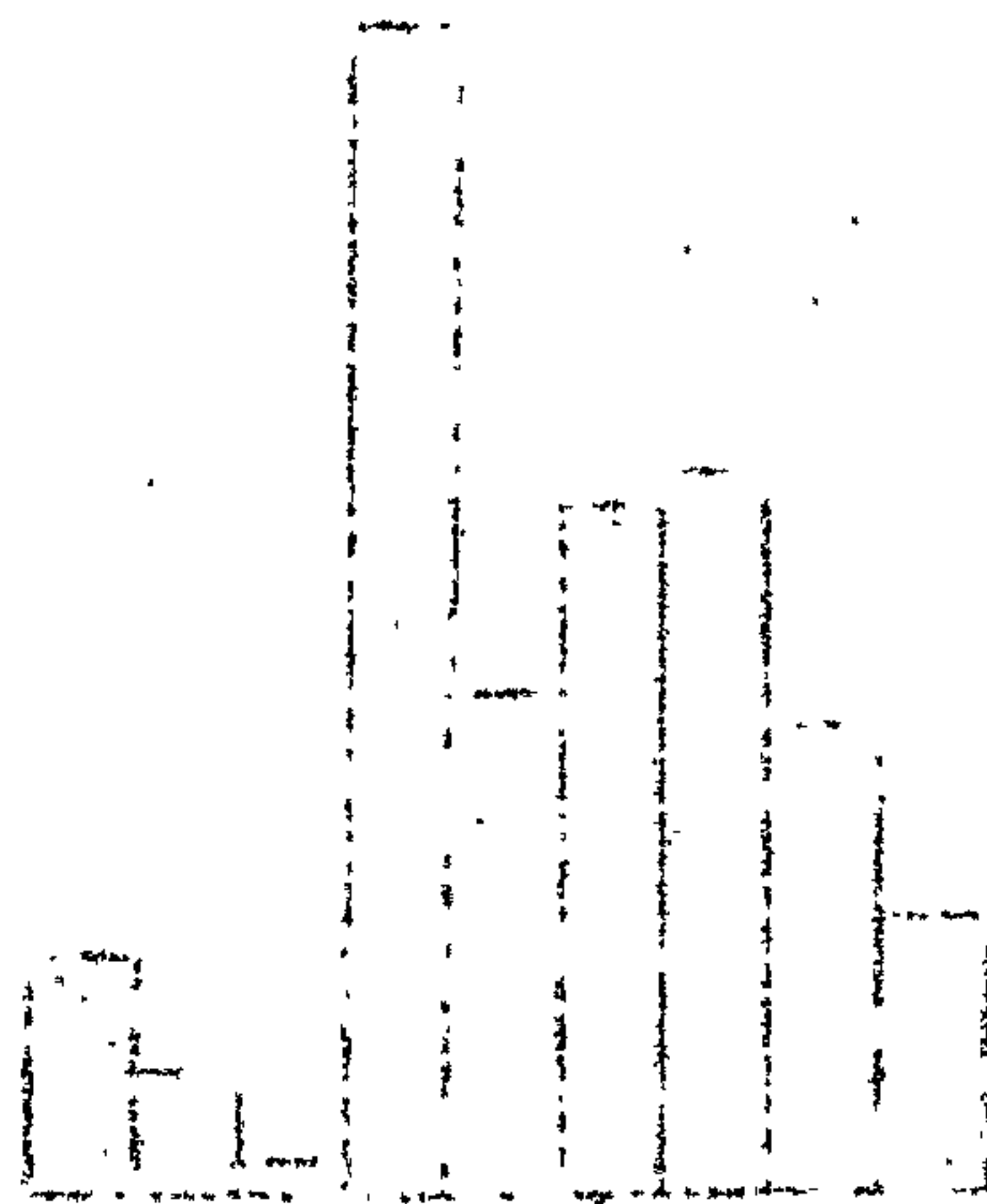


TABLE 1. Histogram showing various means of identification and relative values (Stevens)

The histograms of Stevens⁽⁶⁶⁾ show the relative values of various methods of identification from 13 civil aircraft accidents. The proportions of this histogram is, however, influenced by chance. For example, the usefulness of dental evidence depends as much on availability of ante-mortem dental documentation, as it does on the preservation of the teeth and jaws from destruction in the disaster. Also distinctive clothing is of little value if there is no relative to give a description of what the victim was wearing at the time of the accident. Sex influences the relative values of certain aids to the identification of bodies; documents and wallets are often found in men's clothing but women keep these items in handbags which are usually removed from the immediate vicinity of the victim during the accident.



Women in certain socio-economic stratas tend to have greater frequency of dental care than men.

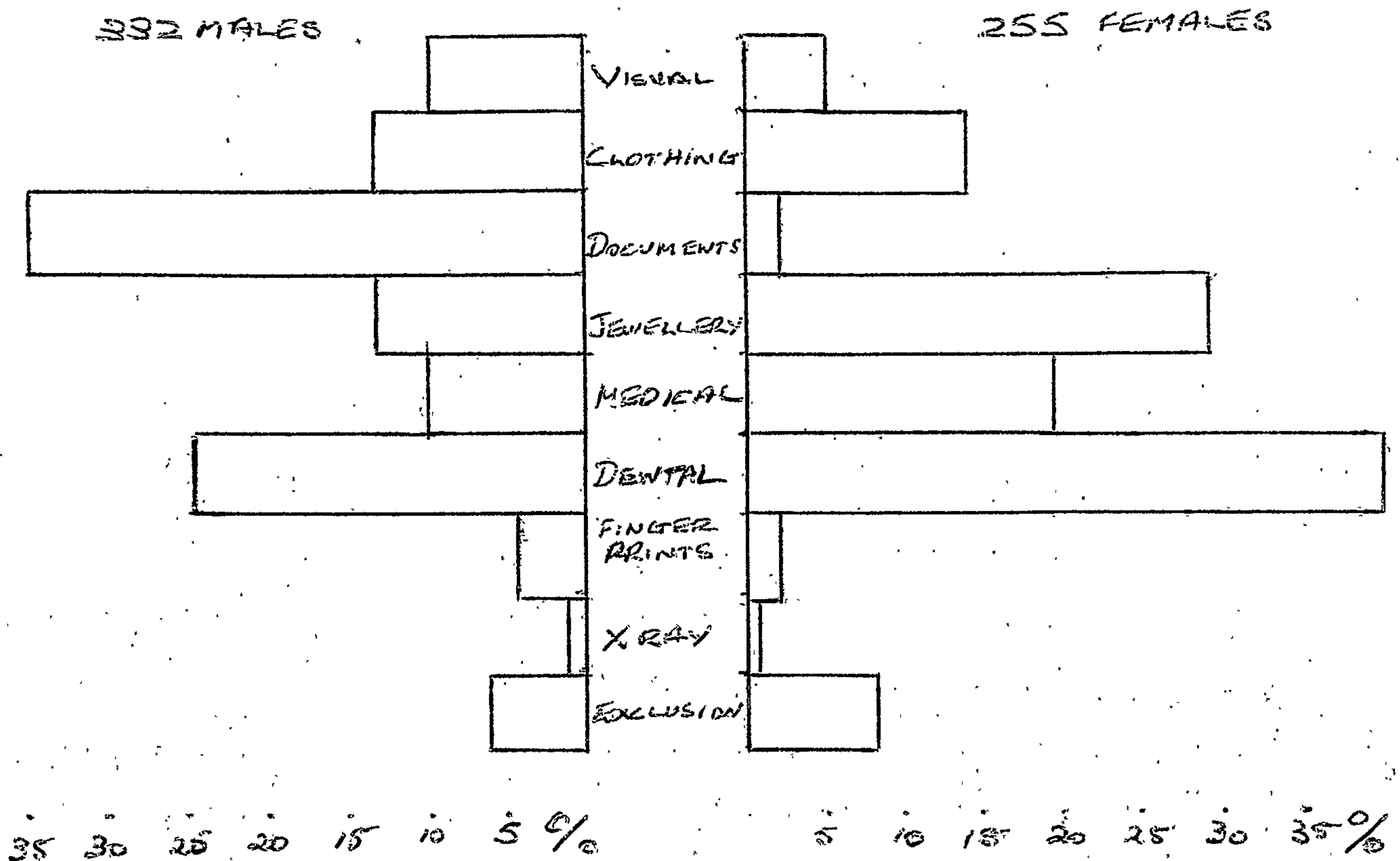
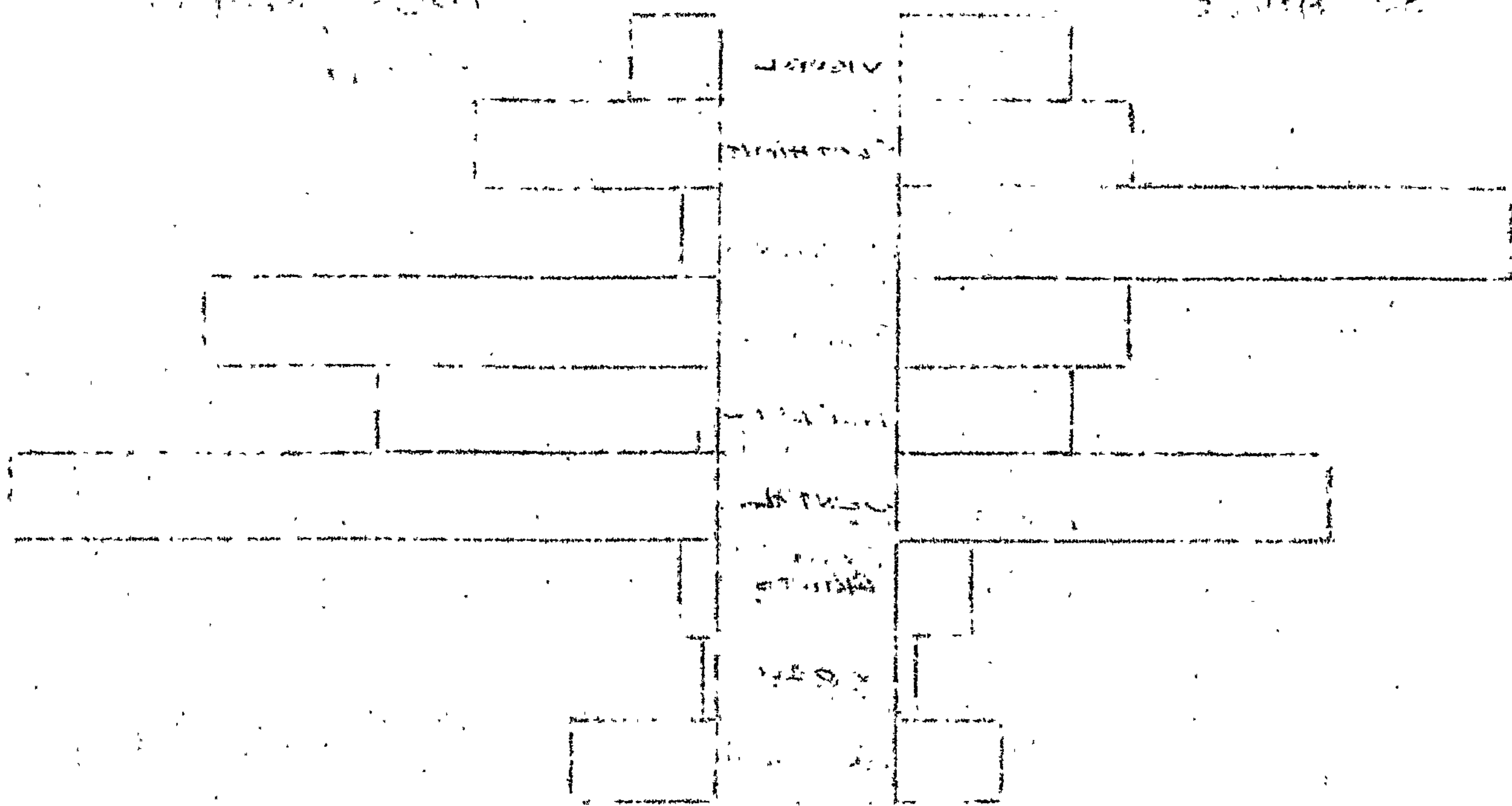


TABLE 2. Histogram showing influence of sex on relative value of each means of identification.

2.1 Visual Identification by Relatives or Friends

Visual recognition by relatives is the most frequent method of identification of bodies brought into most morgues.

Relatives can establish the identity of the body and sign a statement to the effect. Visual recognition is restricted to remains where the physical features of the body, especially facial features have not been distorted by injury or post-mortem changes.



THE HOUSE IS A TWO-STOREY BUILDING WITH A TOTAL AREA OF 1,200 SQ. FT.

THE FIRST FLOOR IS 600 SQ. FT. AND THE SECOND FLOOR IS 600 SQ. FT.

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In modern aircraft accidents the effect of high speed crashes, and more often fire, make visual identification of victims impossible. Incorrect identification by relatives after serious accidents have been frequently reported in forensic literature.

2.2 Personal Effects on Bodies of Victims

Clothing and personal effects are not scientifically reliable as the sole source of identification. Clothing and jewelry may be interchanged between individuals with criminal intent, or may have been borrowed stolen or bought second hand.

2.2.1 Clothing

The clothing of victims in an aircraft accident may be completely destroyed, badly burnt, or torn off the body from blast effects, either those of the explosive forces of ground impact or from the effects of free fall from 30,000 feet if the aircraft disintegrates at altitude. Any remaining clothing may be damaged by rain, fire extinguishing chemicals, blood and other body fluids; thereby rendering an accurate description of the material very difficult. Also small articles such as handkerchiefs which can be borrowed or misplaced at the accident site; these are common sources of error in identification of victims.

2.2.2 Documents

Documents are of a greater value in the identification of male victims because their personal documents are usually found in the pockets of their clothing. However, again, it must be stated that in aircraft accidents involving the modern jumbo jets the speed of impact and usual subsequent conflagration will scatter and move both clothing and documents from the one victim and may deposit them near another, thereby helping to draw false conclusions as to the identity of a body.

2.2.3 Jewellery

Although watches and necklaces are lost or broken in accidents they are often retained on the body. Rings and watches are often inscribed or have a distinctive design and may render useful information which could be verified by the more specific methods of dental and fingerprint records.

2.3 Medical and Radiographical Evidence

A major field of medical evidence is in determination of the sex of a victim in case of severe burning of the body. An estimation of the age of victim can be given from evidence of cranial suture ossification rates and also body viscera, which, often unaffected by fire, can provide clues to the age of an individual.

Internal examination may reveal the presence of a disease which was diagnosed in life. The use of X-ray examinations may show old fractures, arthritic changes and surgical implants which may lead to identification.

2.4 Serology

Little use is made at present of serology in identification of bodies, (Stevens 67). Because of the frequencies of occurrence of the majority of the ABO, MN and RH antigens, positive identification is not possible, however the antigen grouping can help to corroborate other evidence. If whole blood samples cannot be retrieved from the heart, lung or kidney, then oral salivary gland can be used for antigen sampling. Teeth and bones still contain samples of serologically detectable antigens. One interesting study was reported by Boyd and Boyd⁽⁴⁾ who determined the blood group of 300 Egyptian mummies. Extensive research has been carried out by Japanese dentists on antigen grouping from ground sections of teeth. Ohka reports 100% agreement with this method and that of test results using whole blood even when the teeth used have been exposed to the atmosphere for up to eighteen months.

2.5 Finger-printing in Identification

Finger-printing of the general population is common in many countries especially in Japan, Turkey and the United States of America. The FBI Fingerprint Division holds fingerprint files on 84 million persons living in the United States. In the United Kingdom and in Australasia, only criminals and persons in high risk occupations are finger-printed, so few ante-mortem prints would be available for comparison for victims of these nationalities. However in the modern aircraft disaster even involving a country's internal airlines, the passenger manifest would comprise of persons of many nationalities, so wherever possible fingerprinting should be routinely carried out on mass disaster victims (especially those involving hotel, train and aircraft accidents). When there is an aircraft manifest which names all victims, only one half of the print region of a given finger is necessary for identification. This can be important where only a single finger is retrieved, but identity can still be established. If there are no ante-mortem prints for victims, a search can be made of the victims' homes for latent fingerprints on glasses and other household items. Even in cases of severe charring of the body, contraction of body muscles creates clenched fists which often protect the finger pads from being destroyed. The body as a whole, assumes a pugilistic or boxer's stance.



Plate 1

A burned victim, seen in a characteristic pugilistic pose

2.6 Dental Identification

Although fingerprinting is the most common method used internationally for identification, fingers can, and often are, burnt or decomposed, making post-mortem recording impossible. Teeth, however, are the least destructible of all tissues in death. The populations of most 'civilised' communities suffer the ravages of dental caries; even in the more remote areas the advertising media has spread the gospel of the value of refined foods with a high sucrose content.

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More frequently we are seeing socio-economic groups in under-developed countries with an increasing DMFT index score.

Dental disease often results in dental treatment of some form, either in varying standards of mechanical restoration or by extraction. Both the teeth and the dental restorative material are resistant to destruction and therefore are invaluable in identification. Teeth and dental restoration in adults can provide a great amount of detail; by using both missing teeth and restored surfaces there can be over one billion different possibilities in the dental records of an adult.

The various methods of dental identification will be dealt with in the following chapter.

3. DENTAL IDENTIFICATION METHODS

Nearly all the materials used by dentists for restoring teeth are highly resistant to breakdown by organic agents, acids or fire. Teeth are also highly resistant to attack compared to the remainder of the body (with the exception of bone); enamel, in fact, is by far the hardest body tissue. Even though teeth are the most resistant body structures, fire can still alter the form and texture of teeth.

3.1 Resistance to Fire

A number of studies have been carried out on the effects of fire on teeth and restorations. The first recorded study was carried out by Zillner in 1882. He exposed extracted teeth directly to fire, if the teeth were exposed suddenly to the fire they burst because of rapid evaporation of water from the dentine. If the teeth were raised in temperature slowly, then they do not burst. Even though the dentine burns, the enamel stays in its original shape but turns brown in colour. Schirnding⁽⁵⁹⁾ showed that the enamel cap can be lifted off, if the tooth is slowly heated until the dentine ashes; this was also demonstrated by Berg.⁽³⁾

If a fire reaches intensity rapidly, teeth may burst and the enamel is lost. This can often occur in the aircraft accident situation. The upper anterior teeth are initially protected by the lips but subsequent retraction of the lips leaves the upper anterior teeth unprotected. The lower anterior teeth have often, in the post-mortem situation after fire, broken off at the neck of the tooth leaving the root still embedded in bone. If the teeth are intact they may be very brittle and disintegrate if touched. A forensic odontologist should be present at accident sites to help in collection of badly burnt bodies so that he can record and preserve any brittle teeth. These teeth can be preserved using a quick setting clear acrylic or if placed in a diluted cellulose varnish and then dried, Gejuall. (18)

Teeth become brittle at temperatures between 200-300°C. (Mannerberg)^(44, 45), and can become completely ashed at temperatures ranging from 500 - 630° C. (Scott).⁽⁶²⁾

Most gold alloys melt in the range 870 - 1095° C, whereas amalgams vary in melting points due to variations in the alloy composition. Scott also states that the resistance to fire is difficult to predict for silver amalgam, because of the variable amounts of mercury which may be in the amalgam just prior to insertion. Some silver amalgams may disappear completely at low temperature incineration, whereas others may remain intact at temperatures up to 900° C.

After burning silver amalgam restorations resemble cigar ash and crumble easily, (Teuber) (70), the mercury which has not vaporised may be found in the radiographs of this mandible and free mercury globules are often found deep in the burnt tissue.

3.2 Age Estimations

The deciduous dentition commences calcification in the second to fourth month before birth, and continues forming until the completion of the structure of the deciduous second molar at about 2½ years of age. The permanent dentition commences calcification just before parturition with the incised edge of the upper centrals and also the tips of the cusps of the six year molars being first to calcify. Coronal calcification for permanent teeth continues until the 15th to 16th years when the third molar crowns have completed calcification. Permanent tooth root formation begins about the fourth year and continues to about 21-23 years of age. The prenatal apposition of enamel and dentine is regular and has a fairly even growth rate (3µm to 8 µm per day for enamel). This is because of the relatively static environment of the foetus' parasitic existence. At birth the individual's apposition rates of ameloblasts and odontoblasts may vary due to environmental conditions.

In enamel and dentine, areas of hypocalcification show alterations in cellular deposition, the neonatal lines in both enamel and dentine are specific and have been positively correlated with birth and the disruption to the infant in transition from intrauterine to extrauterine existence.

3.2.1 The Eruption of the Deciduous Dentition

The first of the primary teeth usually erupt from the fifth month of life onwards. From this time up to when the child is 2½ years old, the child's age can be estimated by the stage of tooth eruption. There is always a range about the mean of about two months, on either side, (Koski and Garn)⁽³⁵⁾, this is taking two standard deviations on either side of the mean. However other estimates by other researchers dispute this result. Eruption of the deciduous dentition is little influenced by environmental factors; children in different countries have eruption times which vary only slightly, (Adler)⁽¹⁾ According to some authors such as Schonoz⁽⁶¹⁾ it is impossible to accurately judge the age of a child between the ages of 2½ and four. However others determine age during this period by estimations of permanent tooth crown formation, together with completion of formation of the roots of the deciduous teeth. Shortly after the deciduous tooth roots are completely formed, resorption starts taking place. This resorption progresses according to the rate of skeletal growth and the developmental rate of the permanent dentition.

It is also important to distinguish between incomplete root formation and root resorption - sometimes not an easy task. Another characteristic which helps in age determination in the 4 year age group is that, usually at four years of age there is spacing between the deciduous teeth, however in some cases, there is no such space, and a negative finding does not necessarily mean an age below four. Many children show marked attrition of the deciduous dentition which can be a help in corroborating other evidence of age.

3.2.2 The Permanent Dentition

There are many charts showing the development of the human dentition; most of these show only eruption dates and do not include other valuable information (for calculation of age) such as commencement of mineralization, stage of crown formation and the completion of the apical portion of the root. Estimation of eruption time is further complicated by the fact that some authors consider a tooth to be erupted when it first breaks through the mucosa, whereas others take eruption to be the time when the tooth comes into close contact with the opposing teeth, (Sutow⁽⁶⁰⁾). The World Health Organization (WHO) have taken the time when the tooth first erupts through the oral mucosa to be the tooth's eruption time.

The first of the dental development charts to receive widespread usage was produced by Schour and Misslar. (60) This was based on a survey of jaw sections from thirty American children carried out by Rogan and Bronfeld. (40) The chart consists of a series of twenty illustrations of different stages of development from birth to thirty five years of age,

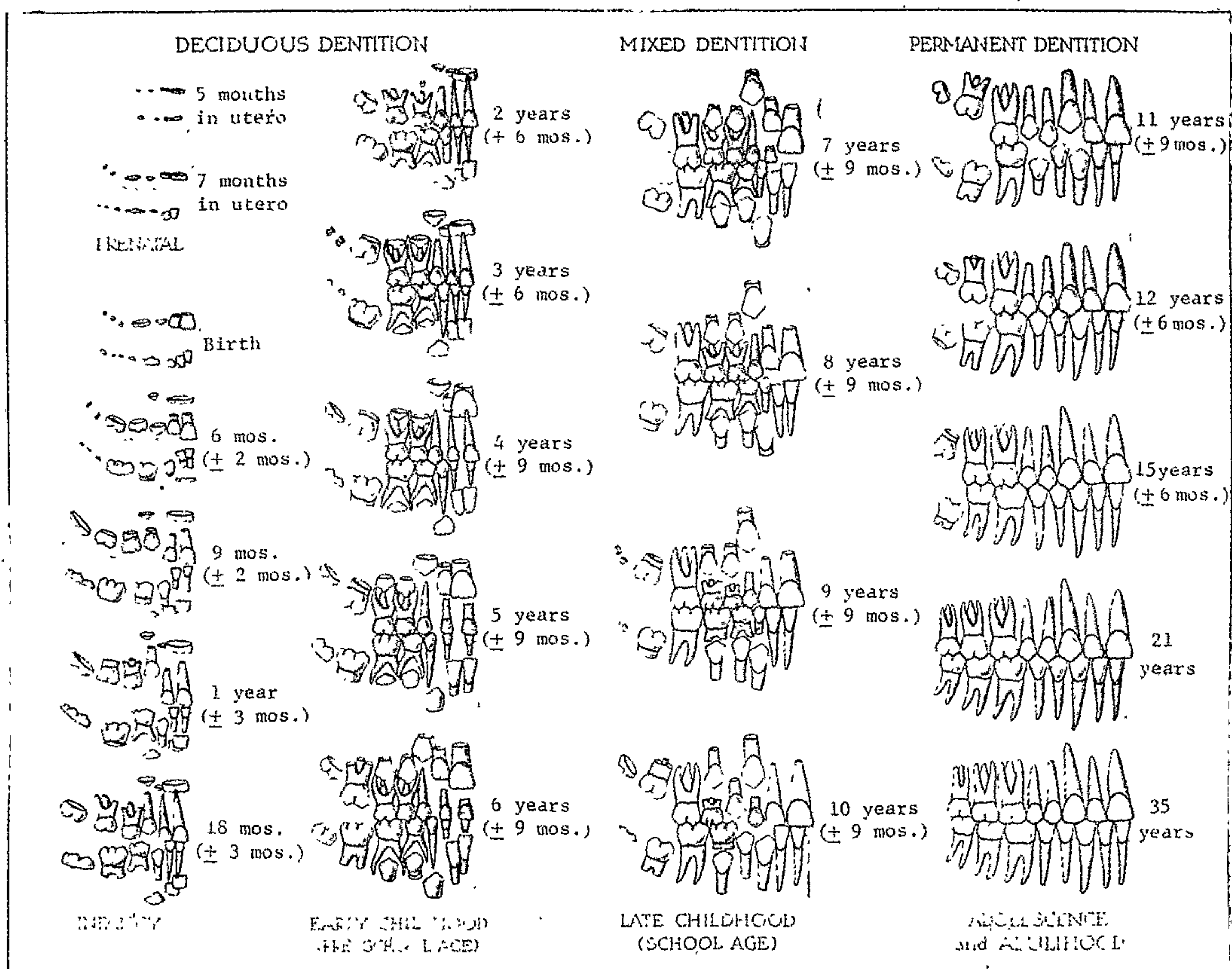


TABLE 3. The development of the human dentition (from Schour, I., and Massler, M).

Moorrees, Fanning and Hunt (52) published a development survey based on radiological data of both the deciduous and permanent dentitions.

Radiographs of 380 American school children were used for the study of the deciduous dentition. In this radiographic study, six stages of crown development and five stages of root development were recorded in the chart, as well as the average or mean development time for each stage. The time difference for two standard deviation either side of the mean is also recorded, so that the age range then is representative of 95% of the population.

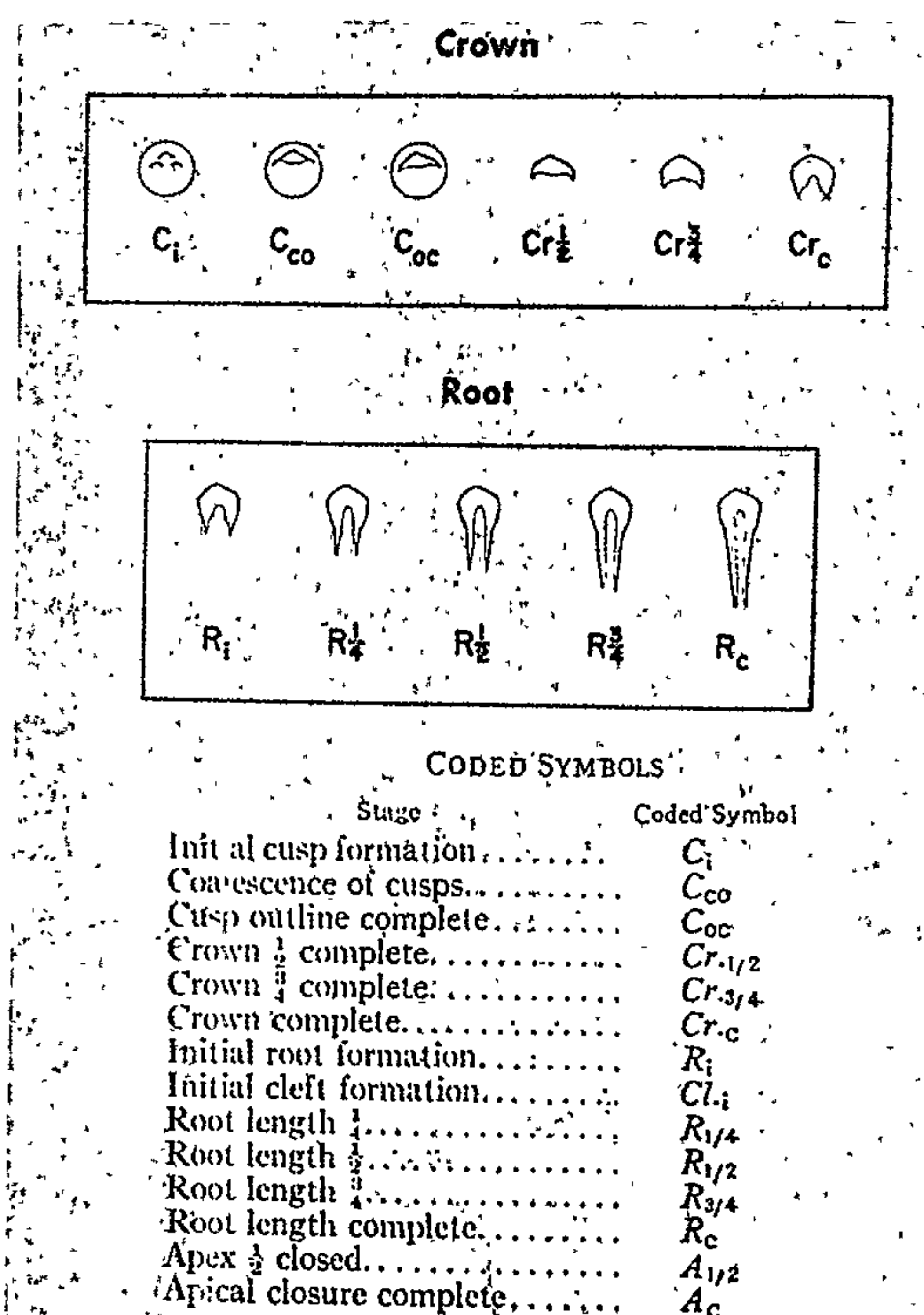


TABLE 4 Outline of various stages of tooth development
(Moorrees, C.E., Fanning, E.A. and Hunt, E.E.)

However because of bone super-imposition encountered in distal areas of the maxilla the Moorrees chart does not record the development of maxillary molars or premolars. The Moorrees, Fanning and Hung chart even with its drawbacks, does provide more comprehensive information on tooth development and age

variations (and also has separate charts for each sex), than does the Schour and Massler chart.

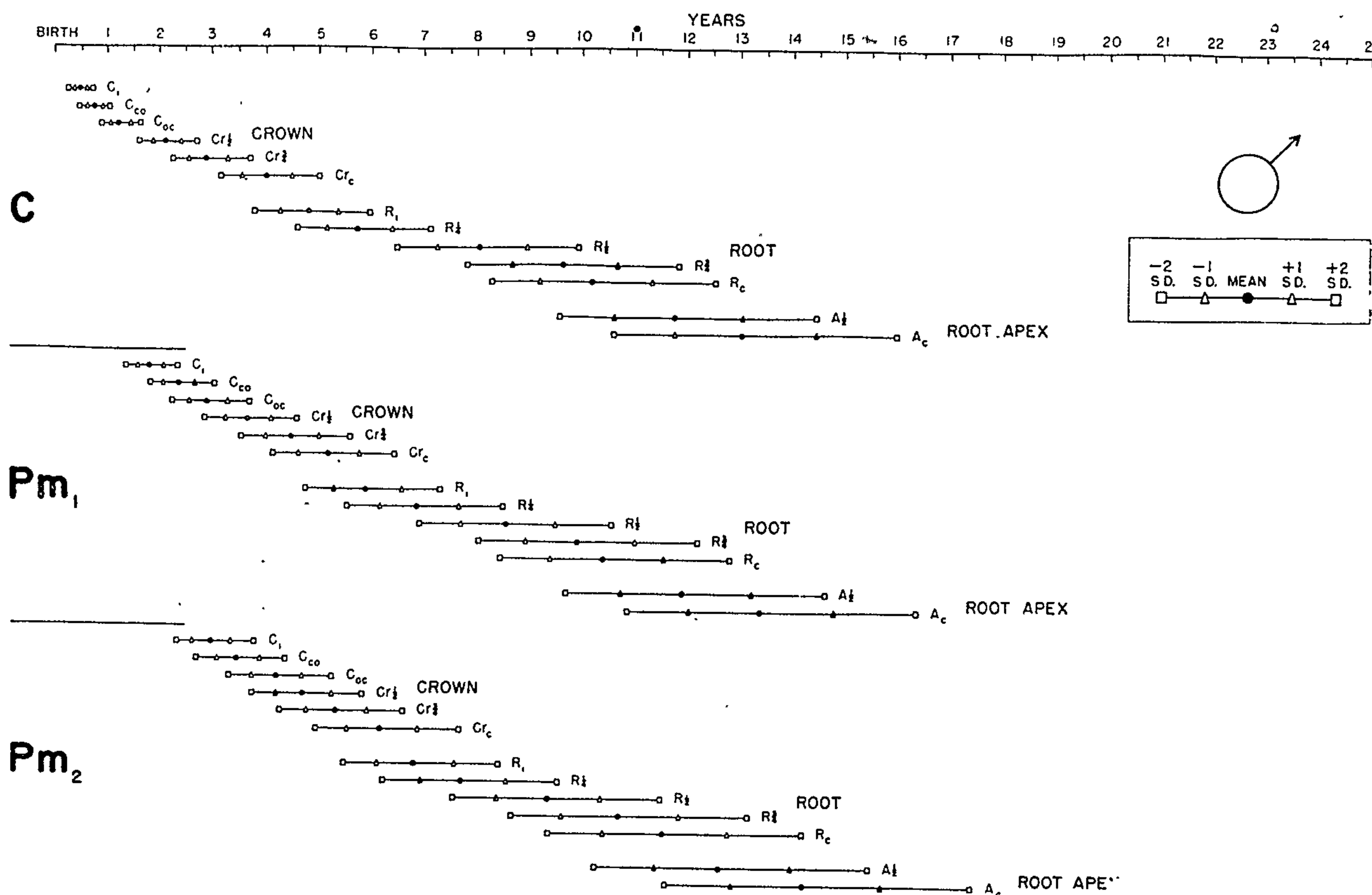


TABLE 5= The chronology of individual tooth development.

Taken from the chart published by Moorress, C.F.A.

Fanning, E.A. and Hunt, E.E.

A further chart has been published by Gustafson and Koch⁽²²⁾ based on data collected from nineteen sources. It included studies by Logan and Kronfeld⁽⁴⁰⁾, Schour and Massler⁽⁶⁰⁾ and Lysell, Magnusson and Thilander⁽⁴⁹⁾. The chart gives a schematic representation of tooth formation and eruption from birth up to sixteen years of age.

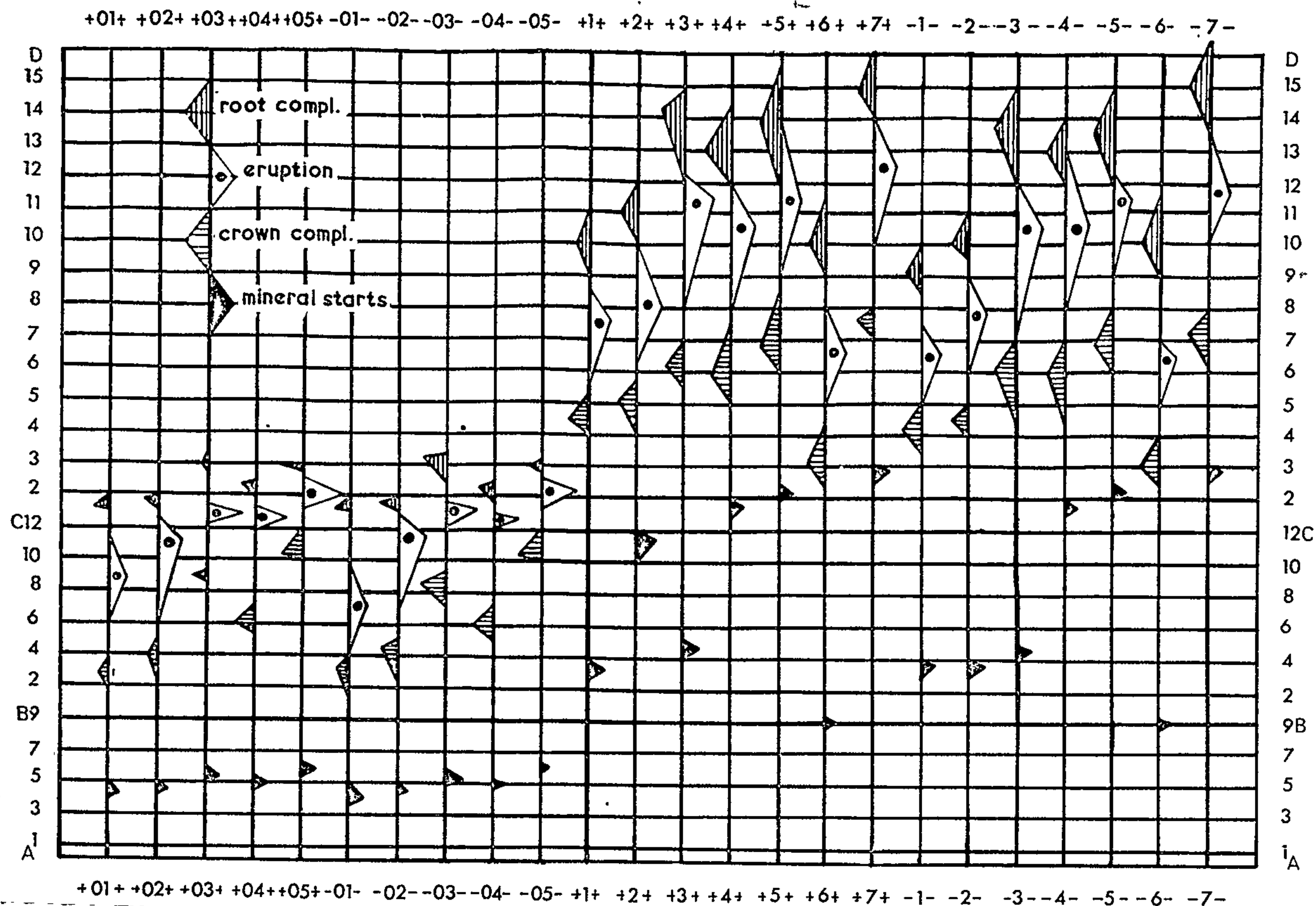


TABLE 6 Diagrammatic representation of dental development taken from Gustafson, G. and Koch, G. cited by Johanson (1971). Each triangle represents one of four landmarks in tooth formation; the commencement of mineralization, the completion of crown formation, eruption, or the completion of root formation. For each landmark, the apex of the triangle represents the average, and the upper and lower angles the oldest and youngest ages encountered in the study.

The Schour and Massler chart has had the widest and longest usage. This study however, was carried out on a small sample of children who were chronically ill, and their medical condition may have affected their eruption and development time. Studies carried out by Garn, Lewis and Palacheck⁽¹⁷⁾ and similarly by Brauer and Bahadur⁽⁵⁾ found that up to one third of their samples fell outside the Schour and Massler ranges. Other workers have carried out extensive surveys on the time and sequence of eruption of the permanent dentition. A notable study was that of Clements Davies - Thomas and Pickett⁽¹²⁾ which was carried out on a sample of nearly three thousand British school children.

Stack⁽⁶²⁾ devised a method of age estimation, which measures the progressive increase in weight of the developing dental tissues.

Stack removed the developing teeth from jaws of a known age and constructed a regression line of weight against age. When the square root of the total dental tissue weights is compared with the postnatal age, a straight regression is obtained for infants spanning in age from five months interutero up until seven months after birth; this survey although ingenious is rather limited in application.

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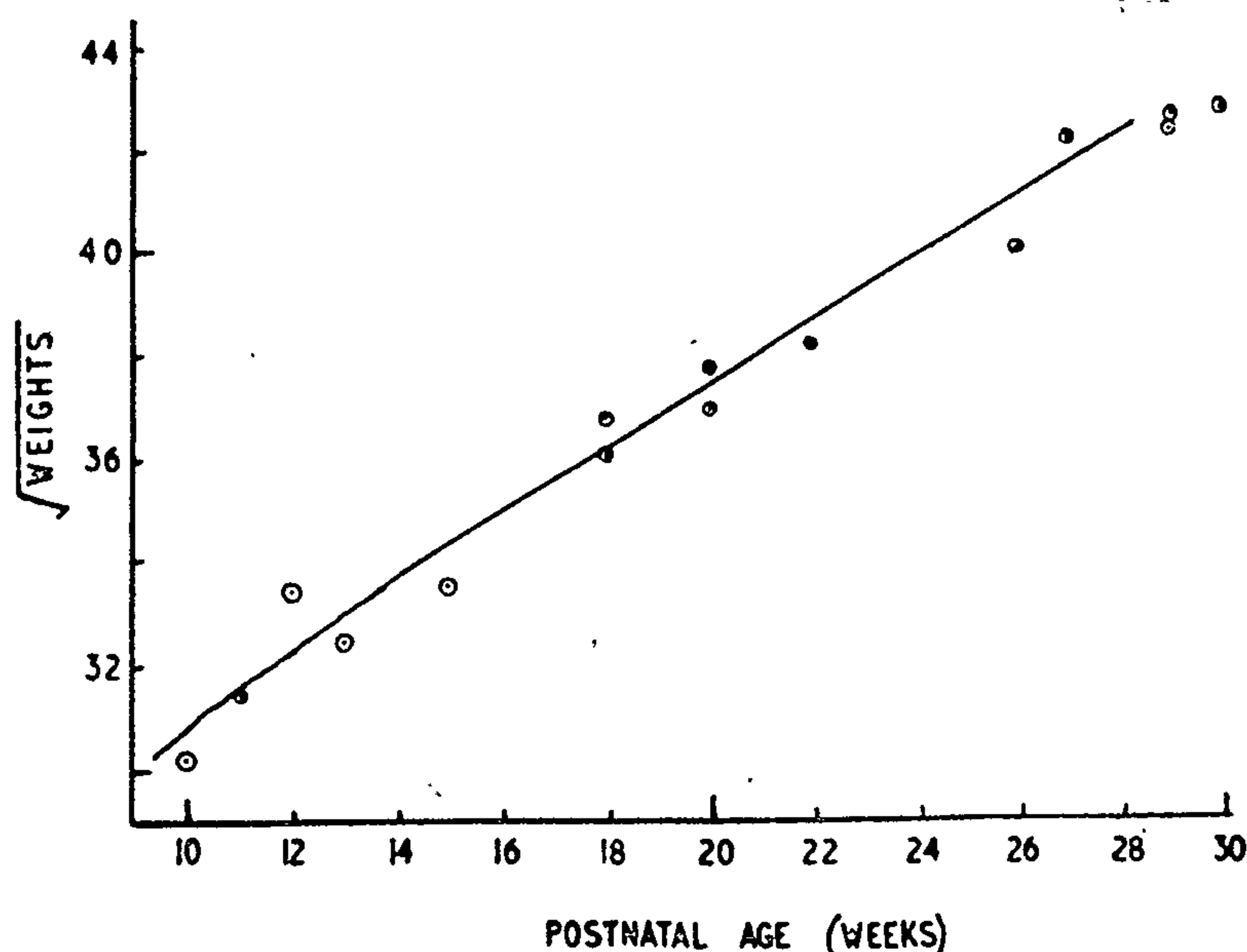


TABLE 7 POSTNATAL AGE (WEEKS)

Regression line of square root of tooth weight compared with postnatal age. Taken from Stack, M.V. (1960).

A method of identifying children in a mass disaster was devised by Ashley⁽²⁾. In this method, teeth which were commencing calcification or in which root formation was nearing completion, were removed to provide a rapid estimation of dental age. This method was first used in 1969 when a Boeing 727 crashed at Gatwick airport resulting in 47 Asian victims who only had five restorations between them. Among the 47 victims there were 16 passengers who were less than 16 years of age. Estimation of age was made on the degree of development of certain teeth and 14 out of the 15 were primarily identified by this means.

(U.S.) Department of State

On July 10, 1968, I was informed by Mr. J. H. Smith, Jr., Director of the Bureau of Land Management, that the Bureau had received a letter from the National Park Service dated June 17, 1968, regarding the proposed acquisition of land for the establishment of a new national park.

• (6.11) *There is a person who is not a person.*

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ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED

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Indemnity for the loss of the property of the insured.

W. J. G. & Co., Ltd.

TO: DIRECTOR, FBI (100-371101) FROM: SAC, NEW YORK (100-100000) (P)
SUBJECT: [REDACTED] (C)

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Ashely made a rough estimation of each victim's age from the state of eruption of the dentition. The teeth commencing calcification or those in which root formation was nearing completion, were removed from the cadaver. Ashley removed these teeth because the tables of dates for dental development gave the narrowest age ranges for these stages. The teeth removed were :

- a. In those victims under one year, an upper deciduous first incisor and its permanent successors.
- b. In the 2 and 3 year old group the lower deciduous first incisor and canine; where these teeth were fully formed, the second deciduous molar was removed.
- c. In the 6 to 7 year olds the lower central incisor (31 or 41 on the FDI index).
- d. In the 11 to 14 year age group, the upper canines with second premolars and if necessary an upper second molar.

The dental age was estimated from the degree of crown and root development. The victims sex (determined by pathologists) and the dental age was matched with the known age and sex of the victims. The table used was the Schour and Massler table with confirmation using the Gustafson table. With the children over the age of twelve the tables by Miles⁽⁴⁹⁾ was also used.

3.2.3 Assessment of Age in the Adult Dentition

After the age of fourteen it is extremely difficult to estimate age from an individual's dentition.

The different features connected with maturation and eruption of teeth has finished, with the exception of the third molar which can show an apical closure variation of up to ten years, Gustafson (19). Therefore any estimation of age from the teeth must be based on additional changes rather than developmental changes. So the changes to be assessed are those of progressive 'wear' and 'tear' changes in teeth.

3.2.4 Gustafson's Method (20)

Gustafson has suggested the use of six separate criteria of progressive change. Each of the six criteria was scored 0-3 with the maximum score of 18; the more severe the age change the higher the score. The six criteria are as follows :

- 3.2.4.1 Attrition or wearing down of the occlusal surfaces.
- 3.2.4.2 Parodontosis or apical migration of the periodontal membrane attachment.
- 3.2.4.3 Secondary Dentine deposition. There is a gradual reduction of the size in the pulp chamber with increasing age.
- 3.2.4.4 Cementum apposition - increase in the thickness of cementum which is accentuated near the apex.
- 3.2.4.5 Root Resorption - usually occurs at the apex (this criteria is often the hardest to score).
- 3.2.4.6 Root transparency - there is increased mineralization of the dentine with ageing,

dentine tubules become obliterated so that the apical areas become transparent to varying degrees when sectioned.

When Gustafson used this method his average error was 3.6 years, (Gustafson) ⁽²¹⁾. Another study carried out by Johanson ⁽²⁹⁾ concluded that the 95 per cent confidence limit is approximately plus or minus 14 years, being a total of 28 years which is a rather broad range. In a study carried out by Malliandian and Sognnaso ⁽⁵⁴⁾ the regression coefficients proved very similar to Gustofson's results, being 4.50 years for the Swedish and 4.61 years for the Boston sample. There was a greater average age error of estimation in the Sognaaso group i.e. 7.9 years in contrast to the Swedish study of 3.7 years. Of the six criteria used by Gustafson, Miles ⁽⁵⁰⁾ found that the area of most translucency proved to be the single most accurate indication of age, however it was still not as accurate as was a combination of the six criteria in toto;.

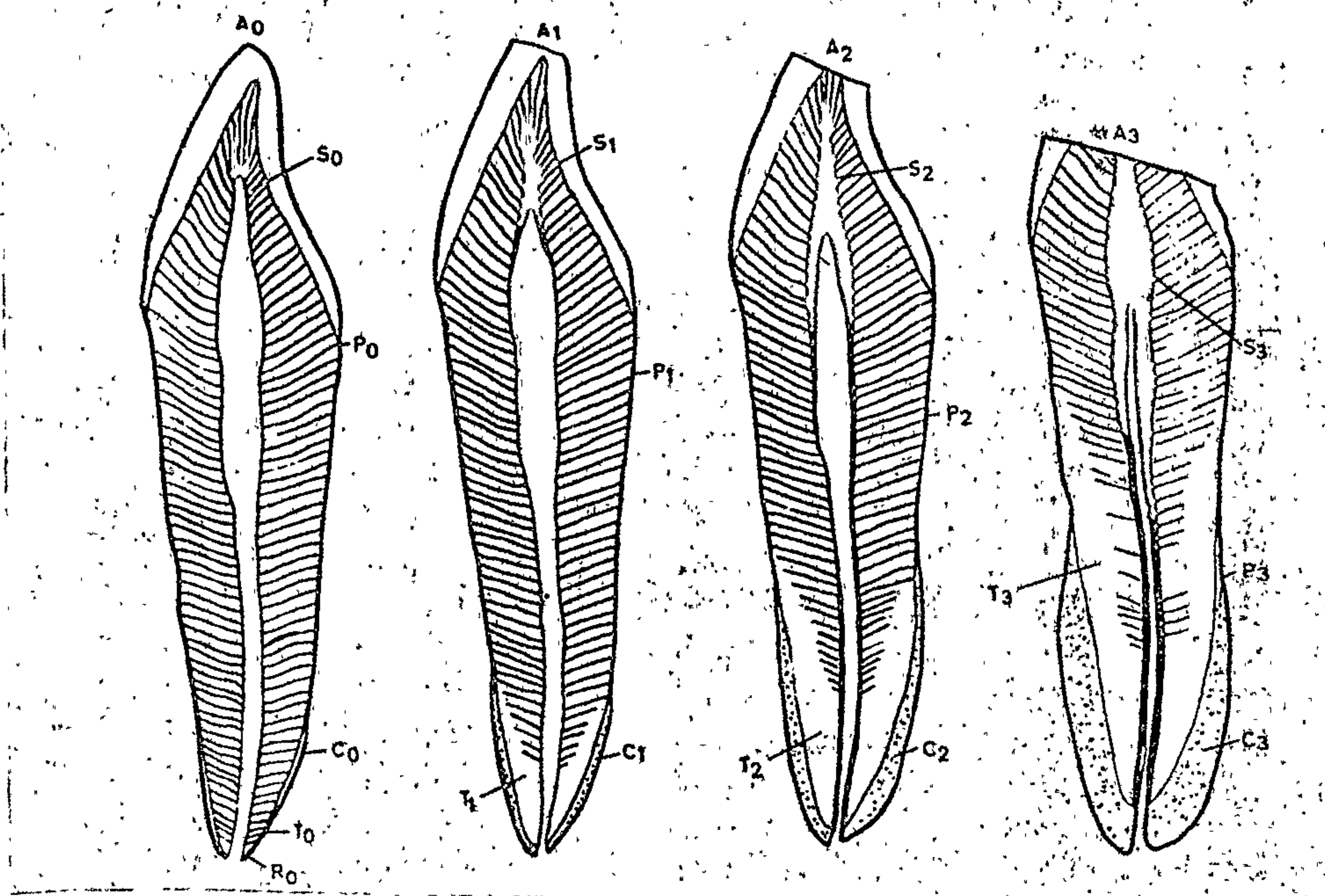


TABLE 7. Six changes found in teeth accentuated by age taken from Gustafson, G. The changes are A=attrition, S=secondary dentine deposition, P=apical migration of epithelial attachments, T=root transparency, C=centrum opposition and R=root resorption. The stages are each represented by a points from 0-3.

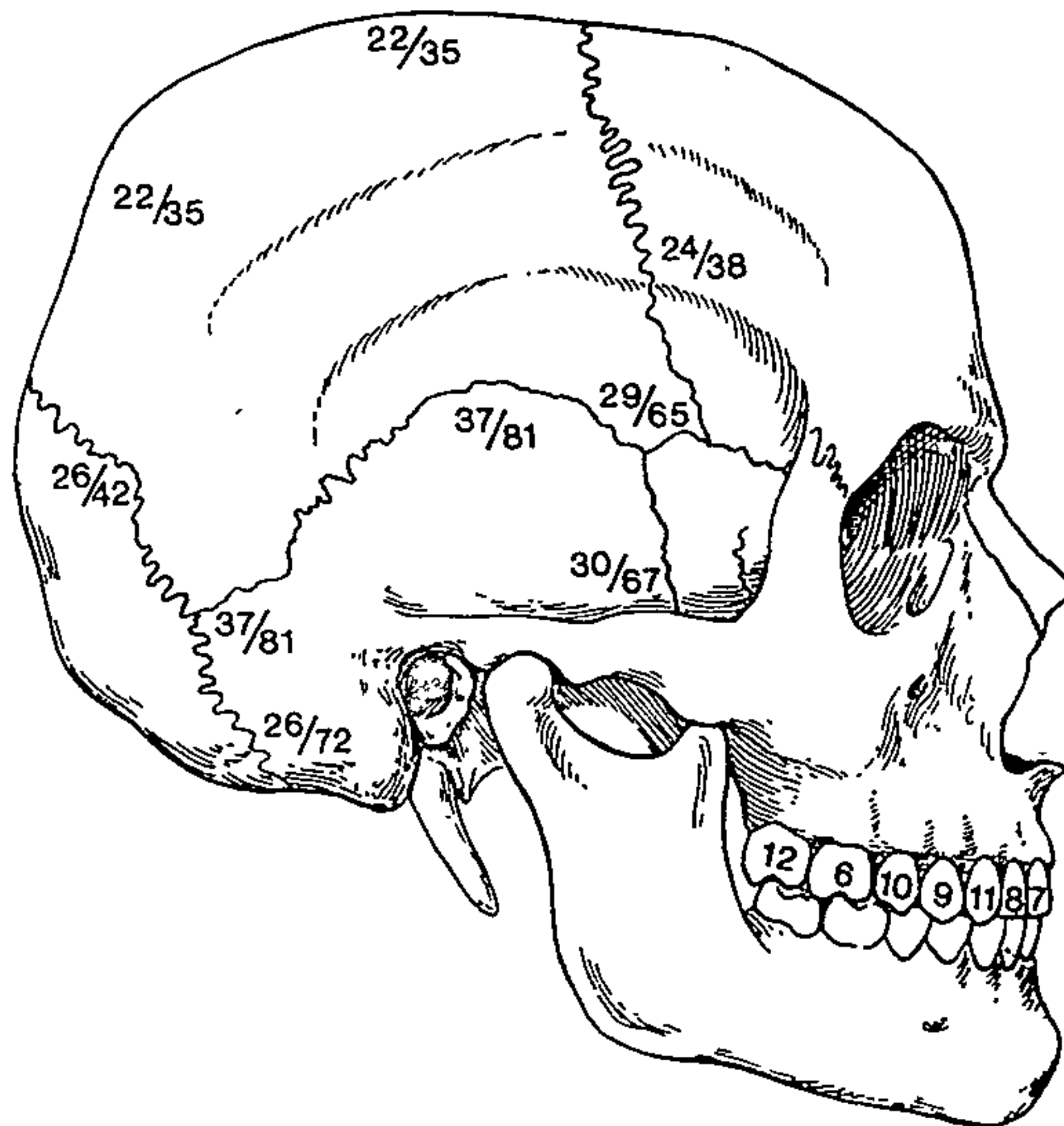
The Gustafson Method has some drawbacks, one being that the investigator needs a good training in dental histology together with facilities for sectioning and mounting of specimens. The accuracy in the estimation of age in this method is of little use over the age of fifty when the 95 per cent confidence levels are up to $\pm$ or - 14 years.

The age estimation using the dentition can be used in corroboration with the sutural closure times in the skull. Suture closure in

the skull as does tooth eruption, shows a great range of variability. Closure generally begins on the inside (endocranially) and proceeds to the outside (ectocranially). The onset of internal suture closure varies with the suture and then proceeds to close at a variable rate to ectocranial termination. There are both ethnic and sexual differences in closure rates, people of negroid origins tend to have earlier initial and final closures than do people of European ancestry (as shown in the following table).

TABLE 8

Fig. 5. Closure ages of the major sutures in the adult human skull are demonstrated. The upper figure indicates initial endocranial closure, the lower figure the age at which obliteration is complete. The number on the upper teeth indicates the age of prominent tooth eruption—incisors through second molars. (After Montagu, M. F. A.: A Handbook of Anthropometry. Springfield, Illinois, Charles C Thomas, 1960, p. 57.)



SUTURE	ENDOCRANIAL INITIAL	ECTOCRANIAL TERMINATION
Sagittal	22	35
Sphenoparietal	29	65
Coronal	24	38
Squamosal	37	81*
Sphenotemporal	30	67
Lambdoid	26	42
Masto-occipital	26	72
Sphenofrontal	22-26	64

*Rarely undergoes complete closure.

TABLE 9 Average age of Sutural Closure in Males

3.3. Identification of Sex and Race

3.3.1 Sex

With a full adult skeleton present, sexing can be carried out by an expert with a 98% success rate. The rate of success with the skull alone is 90%, and 95% with the pelvic bones alone. This is much higher rate of sex identification than can be gained from dental criteria.

3.3.1.1 Skull

The determination of the sex of the skull, depends on the measurement of various sizes and traits.

Features measured are general size and architecture, the degree of muscular markings; supra-orbital ridge size, depth of symphysis menti, breadth of palate, contours of the forehead and development of zygoma. Other features of the male skull that are more pronounced are: mastoid process, base of the skull and occipital region. The male orbits are more square and the nasal apertures are higher and narrower with sharp margins, the mandible is more rugged and square-chinned. The female skull is rounder or more infantile with larger orbits, there is also a higher and rounder forehead with smooth small or absent supraorbital ridges. A table of diagnostic traits of the skull by Krogman (37) is as follows:

TRAIT	MALE	FEMALE
General size	Large (endocranial volume 200 cc more)	Small
Architecture	Rugged	Smooth
Supraorbital ridges	Medium to large	Small to medium
Mastoid processes	Medium to large	Small to medium
Occipital area	Muscle lines and protuberance marked	Muscle lines and protuberance not marked
Frontal eminences	Small	Large
Parietal eminences	Small	Large
Orbits	Squared, lower, relatively smaller, with rounded margins	Rounded, higher, relatively larger, with sharp margins
Forehead	Steeper, less rounded	Rounded, full, infantile
Cheek bones	Heavier, more laterally arched	Lighter, more compressed
Mandible	Larger, higher symphysis, broader ascending ramus	Small, with less corpal and ramal dimensions
Palate	Larger, broader, tends more to U-shape	Small, tends more to parabola
Occipital condyles	Large	Small
Teeth	Large; lower M ¹ more often 5-cusped	Small; molars more often 4-cusped

TABLE 10 Traits Diagnostic of Sex in the Skull (Krogman, W.M.)

3.3.1.2 Teeth and Mandible

Iardaridis⁽²⁷⁾ found that it was impossible to determine sex from mandibular measurements. Ruch⁽⁵⁷⁾ postulates that the mandible is V-shaped in males whereas in the female it is U-shaped, also the angle of the jaw is nearly right angled in the male whereas the female is more obtuse. Ruch, however, arrived at the conclusion that there was such an overlap of measurements between males and females that positive determination of sex was impossible.

A number of studies have been carried out on the differences in size between male and female teeth, Mijsberg⁽⁴⁸⁾, Bruss⁽⁶⁾, Bantz⁽⁸⁾ and Morgan⁽⁵³⁾ but these sex differences were not reliable. Similarly Budin⁽⁷⁾ points out that these measurements constitute only an average not a certainty.

3.3.1.3 Pelvis

The pelvis is the most important part of the skeleton in regard to the determination of sex. The determination as in the skull is based on traits or characteristics and on certain measurements. With a whole pelvis, attention is paid to the shape of the inlet to the 'true' pelvis (heart shaped in the male, and more circular in the female). In the pelvic bones the sizes and direction of the acetabulum which is small in the female and more anterior facing than in the male pelvis.

Also the comparison of the diameter of the acetabulum to the length of the superior ramus of the pelvic bone (equal in the male, but greater in the female). The presence or absence of the pre-aurecular sulcus in front of the sacro-iliac joint, the degree of aversion of the ischio-public ramus and the sub-pelvic angle are all sexual traits which help in getting a 98% success rate in determining the sex of skeletons from examination of the pelvic bones.

3.3.2 Race

3.3.2.1 Skulls

Most of the detailed studies on skeletal differences have been done in relation to American whites and negroes. These skeletal differences are not so much dimensional as proportions, the traits being the shapes of the supra orbital ridges (Mesa-like or undulating), the fronto-nasal junction, Plain or Beetling, the glabella, which can be rounded or Depressed, the edge of the superior orbital margin "Blunt or sharp and the inter-orbital distance narrow or wide. Caucasoid skulls usually present as MBDN (M skulls) whereas the Negroid skulls are USRPW (U skulls). The negroid skulls also have more rounded foreheads with a flattened top; relative to caucasoid skulls. Other measurements such as the Breadth/Length index, the Orbital Height/Breadth index and the Nasal Breadth/Height index, show the negroi skulls as longer-headed, with wider and lower orbits together with a higher nasal index than caucasoid skulls.

For race differentiation, different emphasis is placed on male and female values so that sexing is mandatory prior to any racial differentiation. McKern and Munroe⁽⁴⁶⁾ can differentiate between negroid and caucasoid skulls with a 90% accuracy.

3.3.2.2 Tooth Size and Shape as a Racial Characteristic

Together with the increasing volume of air travel there is also an increasing amount of intermingling of races on various airlines. It would be of great benefit to be able to at least identify the race of the victim from the shape and size of his teeth. However, investigations have been carried out with conflicting results. Krogman⁽³⁸⁾ states that we can only identify the three major sub-species ie Caucasoid, Negroid and Mongaloid. Other investigators such as Lasher and Loe⁽³⁹⁾ say that dental traits may have a higher frequency in one racial group than another, but that no trait is found exclusively in one race.

Tooth shape and size can be used in corroboration with other evidence. In measurements of tooth size, sex must be first known, for there are large sex differences within races. Some of the dental traits which occur in some races with a reasonably high frequency are:

the shovel-shaped upper incisors are a characteristic of the Chinese, Japanese, Koreans, Eskimos and American Indians. These populations express the trait at greater than 85% whereas the caucasoid show only a 45% of shovel-shaped incisors, (Lahser) ⁽³⁹⁾. Hidlichia in 1920 found that non-shovel shaped incisors were rare in Chinese, Japanese and other mongoloid races. Moorrees ⁽⁵¹⁾ found that as well as a high incidence of shovel-shaped incisors in mongoloids, there was also a high incidence of Tori mandibulars and a lack of the cusp of Carabelli on upper molars. Kraus ⁽³⁶⁾ in his premolar studies at the university of Arizona found that negroids had a preponderance of three lingual cusps on the first premolar where all other groups had two lingual cusps on their mandibular first premolars.

3.4 Identification of Occupation

In some dentitions it is possible to obtain clues to the victims occupation. The reason for this is that certain habits are common to certain occupations, such as nail holding groups, such as carpenters and electricians - these groups may have notched incisors or laterals. A corresponding female group is that of the dressmakers and hairdressers. Certain musicians not only damage the teeth but also the gums, and often have callous formation on the lips. Pipe smokers who hold the shaft of the pipe between their teeth often wear away large amounts of tooth structure in both the upper and lower jaws.

Heavy cigarette smokers can also be distinguished by the build-up of nicotine stain on the labial aspect of the anterior teeth whereas with pipe smokers, the stain is often on the lingual or palatal surfaces of the teeth. Also the palate of heavy smokers can show stomatitis nicotinia, with its white raised thread-like tissue and red spots.

It is possible to gain some idea of a victim's nationality from the type of restorative work found in the teeth. Despite some overlapping, dentistry practiced in the United States can vary in different locations. East Coast dentistry differs from West Coast dentistry which differs from Midwestern dentistry. American dentistry differs from Canadian dentistry, which has been influenced by British techniques. On the East Coast of the United States, amalgam restoration tends to be small and circular and as many as six may be placed in one tooth, whereas in Midwest silver fillings tend to be broad, perhaps extending across one third the width of the tooth. In the Western states the restorations tend to be very narrow and very deep. Gold foil restorations are carried out more on the West Coast and can be distinguished from inlays by being more yellowish in colour.

Internationally, Swedish dentistry is very different from that of Eastern Europe, where stainless steel crowns are used very little, ^{or}no coronal preparation. In Britain under the National Health Service most restorations are amalgam; usually broad and nearly always cover the occlusal mesial and distal

surfaces of the tooth (few two surface amalgams) whereas the dentists from France, Germany and Switzerland use more gold inlays and crowns in their restoration of the premolar and molar teeth. In Australia, there was a trend towards the British type of dentistry with broad coverage of amalgams. With the advent of fluoridated water supplies in N.S.W., the cavities and also the restorations have become smaller. The Sydney water supply has been fluoridated for ten years, whereas the Melbourne water supply is not fluoridated. In Sydney the under-10 year olds would have a much lower DMFT than would children of the same age from Melbourne.

3.5 Identification Procedures

3.5.1 Initial Groupings

Previous sections of this chapter have discussed the establishment of the initial points of identity such as approximate age, sex, height and, if possible, the race of the victim.

Victims can then be divided into groups so as to reduce the number of comparisons to be made ie, it is of no use comparing the ante-mortem records of an adult male victim with the post mortem records of a female or child. If there has been a positive racial identification, then the initial grouping should be race. Then each racial group should be subdivided into four groups as follows:

Racial Groups

Adults

Children

Male

Female

Male

Female

The children would be arbitrarily grouped as those under the approximate age of sixteen. These groupings would drastically reduce the numbers of comparisons to be carried out, and therefore would be a great time saver (each comparison can take up to twenty minutes on the average).

3.5.2 Specific Groupings

When the groupings have been established, then the individual mouths can be examined for distinctive features, which may be specific for one individual. If there are a number of specific features, Stevens suggests seven and Keiser-Nielson⁽³²⁾ requires ten concordent features as do fingerprint experts, for positive identification. The specific features to look for would be:

1. Number of teeth.
2. Restorations and prosthesis.
3. Dental caries.
4. Endodontic treatment.
5. Malposition and rotation of tooth.
6. Bone patterns.
7. Peculiar shapes of teeth.
8. Dentures.
9. Relationships of the bite.
10. Oral pathology.

Most identifications are established by the first three criteria, that is, location of missing teeth and the location of surface involvement of restorations, bridgework and caries.

3.5.2.1 Number of Teeth

Teeth may be extracted for relief of pain or infection, orthodontic considerations, traumatic evulsion, or may have been congenitally absent. When teeth are extracted at an early age it is usually for relief of pain or that teeth have become unrestorable due to caries. This is more frequent in lower socio-economic groups which also show neglect such as untreated caries and periodontal diseases. Not infrequently the entire crown portion will have been destroyed or broken off leaving the root protruding from the jaw. Traumatologically removed teeth can only be identified if there is residual soft tissue or bony deformity remaining.

3.5.2.2 Impacted and Unerupted teeth

This usually involves lower third molars, but can also involve upper canines and then less frequently, lower second premolars. The unrecognised existence of impacted third molars may lead to the false conclusion that the subject is less than seventeen to twenty one years old when in fact the victim may be considerably older. Third molar impactions are usually bilateral (unless there is other teeth loss), and the degree and depth of the impaction may vary from left to right side.

The angulation and position of impacted third molars can be of great benefit when trying to identify a victim who is caries free. Periapical X-rays should be routinely taken of the third molar region, if these teeth have not erupted. The apices of the third molars fully close from about nineteen to twenty five years of age, thus giving the forensic odontologist further help in determining the age of a victim.

3.5.2.3 The Drifting of Molars

Although covered in Chapter V, it should be briefly mentioned in this context. This term refers to the fact that upon the loss of a molar tooth, a subsequent eruption or even erupted molar may drift forward and occupy the space of the extracted tooth. If the drifted tooth has been restored on its occlusal surface, thereby destroying its occlusal anatomy it is difficult to distinguish between the drifted tooth and the original. This is a further reason for taking periapical X-rays of the third molar region where there are only two lower molars in situ.

3.5.2.4 Antemortem VX Postmortem Tooth Loss

Postmortem tooth loss can be a frequent occurrence both in cases of traumatic accident and of prolonged immersion. Post-mortem loss usually involves anterior teeth with inverted conical roots so that these teeth easily become dislodged by movement. Molars and premolars are less frequently displaced.

In nondecomposed remains the exposed socket of the tooth, (lost after death) will be free of a blood clot and reveal no evidence of haemorrhage. The socket wall is clean and smooth with a feathered sharp alveolar rim. Whereas an old antemortem tooth loss shows varying degrees of bone remodelling and rounding of the socket rim. Within three to five months the socket may be filled with new alvidar bone, however the root outline may still be visible on X-ray examination. The first radiological evidence of healing in an antemortem X-ray, will be fuzziness of the lamina dura due to absorption. New alvidar bone is laid down progressively until the socket is full, this bone is then replaced by mature denser bone. In early stages of the calcification of new bone, the socket will have a granular appearance due to tiny centres of ossification. These centres become larger and then are eventually remodelled and a normal trabecular pattern is established. Throughout this period the lamina dura may remain intact, and the replacement of the granular appearance by that of trabecular pattern may never eventuate, therefore it is unrewarding to attempt to date sockets by their radiological appearance. If there is any suspicion that a socket seen on a radiograph is recent then it should be submitted to histological examination. By histological methods an estimate of minimum time that might have elapsed between extraction and death, may be possible. (Sims) (10)

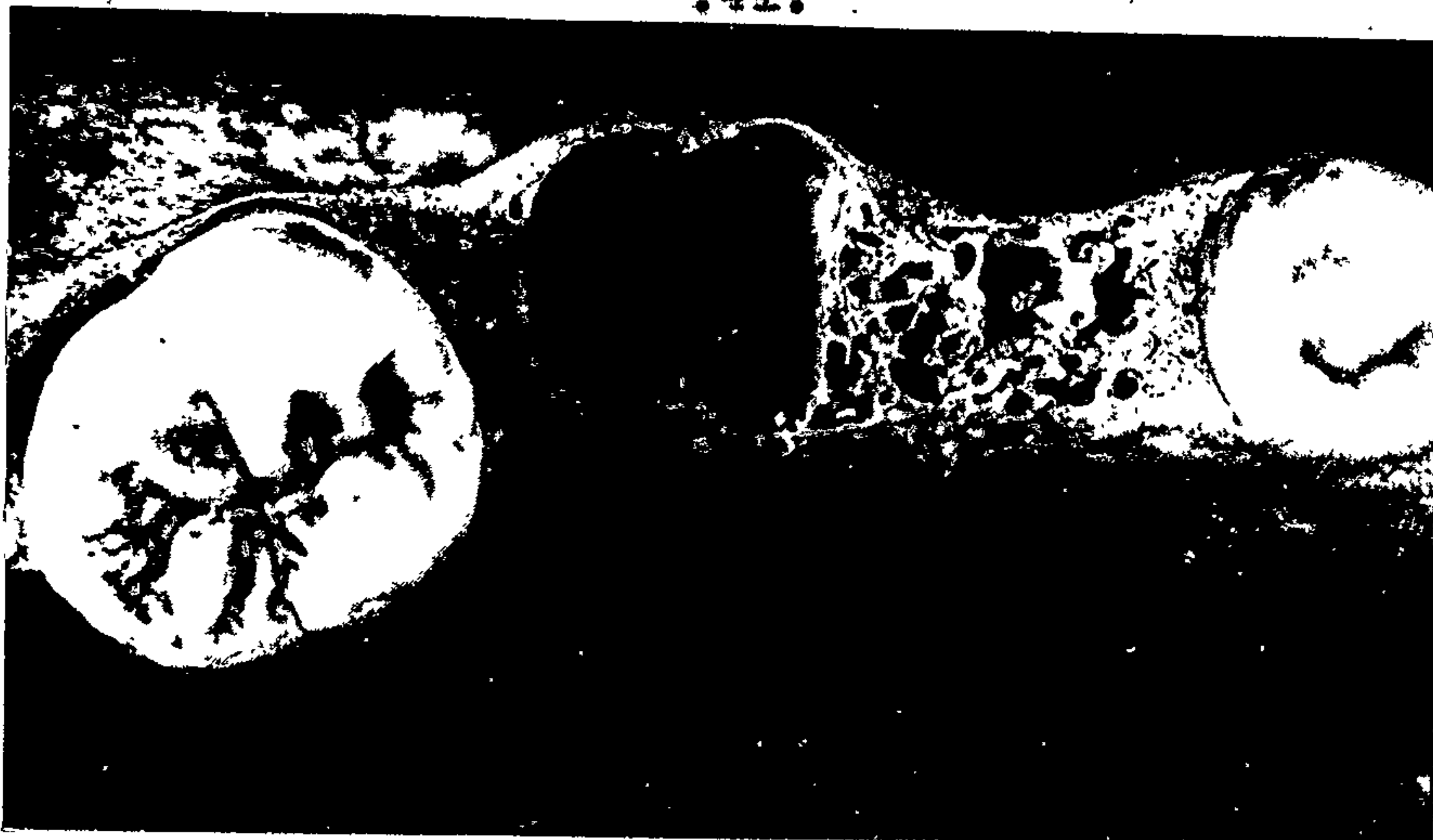


Plate 2

Postmortem tooth loss is characterized by a socket with a sharp rim or edge. The adjacent mesial space shows almost complete remodelling. (Sopher, I.M.).

3.5.2.5 Restorations and Overhanding

MARGINS

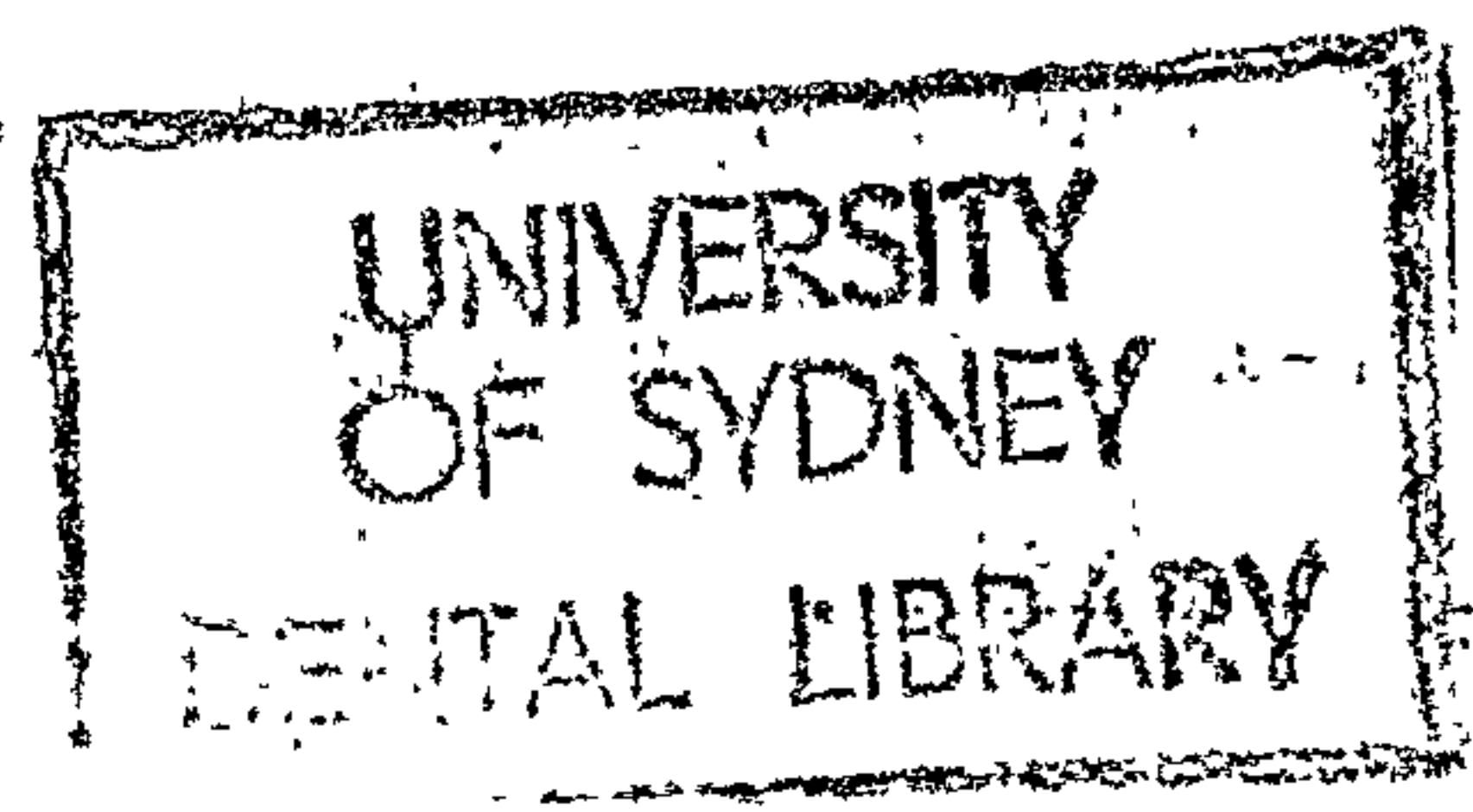
When comparing antemortem and postmortem dental records, a match is sought between two records. This match is found in the combination of missing and filled teeth corresponding with only one other record. If more than two postmortem records match one antemortem record other corroborative evidence must be sought. If any antemortem X-rays exist, then enough specific information can usually be gained from these to confirm the identification.

Initially, for speed of comparison of the records, a specific feature in the records is sought, for example, endodontic treatment, crown or bridgework, pin retention restoration or overhanging margins of amalgam or gold.

...the ...
...the ...
...the ...
...the ...
...the ...

...

...the ...
...the ...
...the ...
...the ...
...the ...



...the ...
...the ...
...the ...

Having a specific feature to look for reduces the comparison checking time. If however the records have no specific or characteristic feature then a number of points of concordance are looked for in the combination of missing teeth and restored tooth surfaces. (Keiser-Neilsen). (32)

With the great numbers of victims involved in modern aircraft accidents, a method of computer comparisons will have to be devised, to check one antemortem record against up to five hundred others. To carry this out manually would take at least one hour for each comparison.

3.5.2.6 Dental Caries

Dental caries should be charted by the surfaces involved and also the shape of the carious lesion should be recorded.

When comparing antemortem X-rays with a postmortem record, special care should be taken so that initially depicted caries on the X-rays is checked against the treatment chart to make sure that the caries was not removed and replaced by a restoration. It is important to take into account the date at which the X-rays were taken, remembering that the main function of X-rays was to demonstrate interproximal caries which was not found in visual examination, and that affected teeth may have been subsequently restored or extracted.

Therefore the most recent X-rays should be sought to avoid any confusion.

Caries areas may lead to undermining of the enamel and subsequent fracture; such fractures are usually adjacent to a decayed area and are most common in molar teeth. Recent traumatic fractures often show fracture into an area of sound dentine and also have a sharp line of fracture.

3.5.2.7 Malposition and Rotation

Malposition and rotation of teeth especially in the anterior region make excellent points of 'concordance'. Few private dental practitioners record rotated or misplaced teeth in their dental chartings. If the patient has been treated at a hospital or military dental clinic, there is a good chance these malocclusions have been recorded. Anterior malocclusions can also be identified from antemortem photographs which show a person's anterior teeth.

3.5.2.8 Peculiar Shapes of Teeth

Congenitally malformed teeth are rare and therefore are a characteristic feature, such characteristics are those occurring with congenital syphilis and peg shaped lateral incisors. Occupational habits which produce unusual wear facets are also characteristic.

3.5.2.9 Endodontic Treatment

Endodontic treatment is specific for it is carried out much less frequently than amalgam restorations; endodontic treatment of a tooth is specific in itself. Endodontic treatment is expensive and therefore puts the owner in a certain socio-economic class. The materials used and method of placement of the endodontic materials may be specific for one country or State. There is usually at least one antemortem X-ray taken during the endodontic treatment of a tooth, so there should be an antemortem X-ray for comparison.

3.5.2.10 Bone Pattern

The alveolar bone often has a characteristic trabecular formation which can sometimes be duplicated on postmortem X-rays. Tooth angulation also affects the level to which bone surrounds a tooth, an angled tooth together with its level of bone are specific features when in combination. Interproximal bone loss due to periodontal disease may also be specific. The position of the maxillary sinus and its relation to roots of molar and premolar teeth should be compared in the antemortem and postmortem X-rays for similarities.

All the above features appear on X-ray film. The major fault of this method is that there is no fixed angle at which the antemortem X-rays were taken, so there is some guesswork in the angulation of the postmortem X-rays.

Sometimes a number of X-rays have to be taken to get the same angulation as in the antemortem X-ray.

3.5.2.11 Complete Dentures

Dentures are discussed in Chapter 4, complete dentures are usually of very little value in identification in mass disasters. Firstly, few of these dentures have any identification tag incorporated in the dentine material and secondly, few dentists ever record the tooth shade and mould used in the denture. In aircraft accidents few complete dentures are found still in the mouth of the owner, most have been dislodged by the force of the impact. In disasters where there is a fire and no other impact trauma dentures would be of great value in identifying the victim if the dentures carried an identification tag (one of the hardest persons to identify is severely burnt persons wearing complete dentures).

A denture marking system should be standardised and be incorporated in legislation so as to make it compulsory for dentists or technicians to incorporate an identification tag in dentures.

3.5.2.12 Relationship of the Occlusion

The relationship of the occlusion would only be of benefit if it was a characteristic feature such as severe Angles Class II or Class III relationships.

This information could be gained from relations as well as from the dentist and could probably be confirmed from antemortem photographs of the victim.

3.5.2.13 Oral Pathology

Although specific pathological conditions of the oral cavity are not common, this very fact imparts varying degrees of specificity to a condition depending on percentage incidence in the population group. Oral conditions that are specific, are; torn, soft tissue conditions of the tongue, and bone pathology such as cyst of dental or bone origin which may have antemortem X-rays for comparison. Other disorders such as Pagets disease, fibrous dysplasia, and neoplasms, can be diagnosed from postmortem X-rays; if these conditions were under investigation before death then this could assist in the comparison. The presence of healing or healed fractures and the establishment of an approximate time of injury could be of help in the identification comparison. Often old fractures contain intra-osseous pins, or plates; pins or plates may be removed and traced by the maker's name to their country of origin.

4. WORLD SYSTEMS OF DENTAL NOTATION

By law in most countries, dentists are required to keep records of treatment carried out for a patient. So that records do not become too bulky, and take up valuable space, various systems of coding or abbreviations have been evolved to reduce the amount of written description required to record dental treatment. Unfortunately, dentistry has developed along national lines, with each country or group of countries having its own method of identifying a tooth or tooth surface. This works well enough when a dentist is conferring with dentists of his own country, however the difficulties increase when a dentist wants to impart his observations to an international audience.

At present there are over fifty four major systems of dental notation in current world use. Hence the problems of transmission of information to help in identification in mass disasters becomes immense. All incoming dental records from around the world would have to be converted from their original form to one standard format recognised by the examining forensic dental teams. The members of a dental team who is recording all incoming dental records would have to be conversant with all the major dental notation systems.

Much of the following material comes from survey of dental systems carried out by Professor Frykholm and Lysell of the Royal School of Dentistry, Stockholm. (15)

These two dentists sent out questionnaires to 190 dental systems schools in over forty countries. From the replies they found that the majority of systems fall into two categories; those having a similar notation for the teeth in each segment, and those having a different number for each individual tooth.

4.1 Systems having a similar notation in each segment

System 1. The oldest method of notation still in use is Zsigmondys (1961) which in the English speaking countries is known as Palmer's Notation (1891). The central incisor in each segment is given the number '1' and then the numbers run sequentially distally. The segments are shown by the symbols $\text{J}, \text{L}, \text{7}, \text{F}$ for the patients upper right, upper left, lower right and lower left segments. For deciduous teeth sometimes the arabic numerals are altered to Roman numerals, also the capital letters A to E with A being the deciduous central are often used. In some systems the letter 'D' for deciduous (sometimes written with a lower case 'dd') is placed before or after the tooth number. Deciduous teeth are also designated by the letter 'm' after the tooth number.

Permanent Teeth: ZSIGMONDY'S SYSTEM

8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8
8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8

Different Variation for Deciduous Teeth

R	V	IV	III	II	I		I	II	III	IV	V	L
	V	IV	III	II	I		I	II	III	IV	V	

R	E D C B A	A B C D E	L
	<u>E D C B A</u>	A B C D E	

R	e d c b a	a b c d e	L
	<u>e d c b a</u>	a b c d e	

R	5D 4D 3D 2D 1D	1D 2D 3D 4D 5D	L
	<u>5D 4D 3D 2D 1D</u>	1D 2D 3D 4D 5D	

RR	d5 d4 d3 d2 d1	d1 d2 d3 d4 d5	L
	<u>d5 d4 d3 d2 d1</u>	d1 d2 d3 d4 d5	

R	5m 4m 3m 2m 1m	1m 2m 3m 4m 5m	L
	<u>5m 4m 3m 2m 1m</u>	1m 2m 3m 4m 5m	

System 2. Another European system employs the angle sign with the numerals 1 to 8 for permanent teeth and A - E for deciduous teeth, in the reverse order to the Päämer Notation ie '1' is the third molar and '8' the central incisor.

R	1 2 3 4 5 6 7 8	8 7 6 5 4 3 2 1	L
	<u>1 2 3 4 5 6 7 8</u>	8 7 6 5 4 3 2 1	

R	A B C D E	E D C B A	L
	<u>A B C D E</u>	E D C B A	

System 3. A system mainly seen in Holland used the angle system, but instead of designating teeth with numbers used the initial letters of the Latin names for the teeth, together with a small letter designating its order in the mouth; small case 'd' precedes the Latin letter for deciduous teeth.

R	M ₃	M ₂	M ₁	P ₂	P ₁	C	I ₂	I ₁	I ₁	I ₂	C	P ₁	P ₂	M ₁	M ₂	M ₃	L
	M ₃	M ₂	M ₁	P ₂	P ₁	C	I ₂	I ₁	I ₁	I ₂	C	P ₁	P ₂	M ₁	M ₂	M ₃	
R	dm ₂	dm ₁	dc	di ₂	di ₁		di ₁	di ₂	dc	dm ₁	dm ₂						L
	dm ₂	dm ₁	dc	di ₂	di ₁		di ₁	di ₂	dc	dm ₁	dm ₂						

System 4. The Haderup system was designed in 1887 and is used fairly universally in Sweden, Denmark, Norway, Finland and Iceland and in conjunction with other systems in Germany, Italy, Switzerland, Yugoslavia, Poland and Czechoslovakia. In the Haderup system the central incisor is numbered '1' and the other teeth in that segment numbered sequentially to 8 being the third molar. The numbers of the teeth are combined with a plus sign for the maxilla and a minus sign for the mandible. The sign is placed on the right side of the tooth number if the tooth is on the patient's right side; and on the left side of the numeral if the tooth is on the left side of the skull. Deciduous teeth as designated with an '0' in front of the tooth number.

Permanent Teeth

HADERUP'S SYSTEM

R	8+	7+	6+	5+	4*	3+	2+	1+	+1	+2	+3	+4	+5	+6	+7	+8	L
	8-	7-	6-	5-	4-	3-	2-	1-	-1	-2	-3	-4	-5	-6	-7	-8	

Deciduous Teeth

R	05+	04+	03+	02+	01+	+01+	00	20	00	04+	00	L
	05-	04-	03-	02-	01-	-01-	02-	03-	04-	05-		

R	V+	IV+	III+	II+	I+	+I	+II	+III	+IV	+V	L
	V-	IV-	III-	II-	I-	-I	-II	-III	-IV	-V	

System 5. A system in use in Holland and some lowland European countries, was the first letter of the Latin word for the teeth together with a segment position. The maxilla is designated by the letter 's' (superior) and mandible by the letter 'i' (inferior), the left and right side are designated by 's' and 'd' (sinister and dexter). These segment reference letters follow the tooth index number; the same method is used for deciduous teeth except the Latin first letter is in the lower case.

Permanent Teeth

R	M _{3sd}	M _{2sd}	M _{1sd}	P _{2ds}	PI _{1sd}	C _{sd}	I _{2sd}	I _{1sd}	I _{1ss}	I _{2ss}	C _{ss}	P _{1ss}	P _{2ss}	M _{1ss}	M _{2ss}	M _{3ss}	L
	M _{3id}	M _{2id}	M _{1id}	P _{2id}	PI _{1id}	C _{id}	I _{2id}	I _{1id}	I _{1is}	I _{2is}	C _{is}	P _{1is}	P _{2is}	M _{1is}	M _{2is}	M _{3is}	

Deciduous Teeth

R	m _{2sd}	m _{1sd}	C _{sd}	i _{2sd}	i _{1sd}	i _{1ss}	m _{2ss}	m _{1ss}	m _{2ss}	L
	m _{2id}	m _{1id}	C _{id}	i _{2id}	i _{1id}	i _{1is}	m _{2is}	m _{1is}	m _{2is}	

System 6. Uses the first letter of the Latin word for the tooth with its designation number placed to indicate the segment. In the upper right segment, the index number is high on the left of the tooth letter and low on the left for the lower left, the apposite applies for the right 'segments' of patients maxilla and mandible.

R	3 ^M	2 ^M	1 ^M	2 ^P	1 ^P	1 ^C	2 ^I	1 ^I	I ¹	I ²	C ¹	P ¹	P ²	M ¹	M ²	M ³	L
	3 ^M	2 ^M	1 ^M	2 ^P	1 ^P	1 ^C	2 ^I	1 ^I	I ¹	I ²	C ¹	P ¹	P ²	M ¹	M ²	M ³	

System 7. Another system which does without angle signs is used to a limited extent in France. This system numbers the teeth from '1' as the central incisor to '8' as the third molar, preceding the tooth number on the right side is a capital 'D' (droite) and capital 'G' (gauche) for the left side. The teeth in the mandible are indicated by a small case 'd' or 'g'.

Permanent dentition

R	D8	D7	D6	D5	D4	D3	D2	D1	G1	G2	G3	G4	G5	G6	G7	G8	L
	d8	d7	d6	d5	d4	d3	d2	d1	g1	g2	g3	g4	g5	g6	g7	g8	

4.2 Systems with different notation in each segment

Several systems may operate in one country, especially in countries large in area such as Australia and United States where vast distances separate dental schools which have evolved under different influences. The most common systems in use in the United States are the Army System, Navy System, Bosworth System and the Universal System. There is a recent trend in use by the Armed Forces, the Veterans Administration,

U.S. Public Health and most insurance companies and welfare institutions. However, forensic dentists must have a working knowledge of all systems in present and past usage, for many dental records from a victim's past military service or other institutions may have used the older systems.

Sydney 8. Army System

R	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	L
	16	15	14	13	12	11	10	9	9	10	11	12	13	14	15	16	

System 9. Navy System

R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	L
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	

System 10. Bosworth System

R	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	L
	H	G	F	E	D	C	B	A	A	B	C	D	E	F	G	H	

System 11. Universal System

R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	L
	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	

With the four main United States systems, deciduous teeth can be designated by two different methods for each system. Firstly, one can retain the number of the first five teeth in each segment and add a symbol to signify a deciduous tooth.

Secondly retain the method of designating the teeth but substitute alphabetical letters for the numbers (used in permanent dentition). Using the first method the Navy put a circle around the tooth number, they then used to put a 'D' around the number (eg 4 25 ;

The Army has modified the Navy system to placing a 'D' after the tooth number to indicate that it is a deciduous tooth.

One Navy System for deciduous teeth

R	A	B	C	D	E	F	G	H	I	J		L
	K	L	M	N	O	P	Q	R	S	T		

Army Systems

R	4D	5D	6D	7D	8D	9D	10D	11D	12D	13D	L
	29D	28D	27D	26D	25D	24D	23D	22D	21D	20D	

Army System for deciduous tooth

R	E	D	C	B	A	A	B	C	D	E	L
	J	I	H	G	F	F	G	H	I	J	

Universal Deciduous System

R	A	B	C	D	E	F	G	H	I	J	L
	T	S	R	Q	P	O	N	M	L	K	

System 12

Another system which operates only in Cincinnati in the United States is a mirror image of the Navy System so that the right and left side are transposed. This again shows up the problems involved in the translation of various systems used on antemortem records into one standard format being the one used for postmortem dental recording.

Permanent dentition

R	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	L
	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	

System 13

Many different systems use the angle sign together with a tooth notation, however, many of these systems are mirror images of one another (either with regard to signs of location or conversions from central incisor to third molar). To try and avoid some of this confusion, a system is in use whereby the mouth is divided into four segments, upper left, lower left, upper right and lower right, designated as UL, LL, UR, LR respectively. The teeth are designated in the same way as in Palmer's Notation 1-8 with '1' as the central incisor (so first molars become UL6, LL6, UR6, and LR6). This system removes many of the problems of the other systems for the patient has only one right side and one upper jaw. The major short-coming of this system is that it cannot be used internationally, because English is the spoken language of only a small percentage of the world's population. This system is in widespread use in Australia and New Zealand and in some areas of Britain.

Permanent dentition

R UR8 UR7 UR6 UR5 UR4 UR3 UR2 UR1	UL1 UL2 UL3 UL4 UL5 UL6 UL7 UL8	I
LR8 LR7 LR6 LR5 LR4 LR3 LR2 LR1	LL1 LL2 LL3 LL4 LL5 LL6 LL7 LL8	

4.3 F.D.I. System

The F.D.I. General Assembly in Bucharest in 1971⁽¹⁶⁾ noted on a resolution proposing that a two digit system should be adopted world-wide; the Assembly carried the resolution by 38 in favour to 11 against. The Committee that proposed this

new system, found that this system was the only one which satisfied its terms of reference that the method should be:

- a. simple to understand and teach;
- b. easy to pronounce in conversation and dictation;
- c. readily communicable in print and by telex;
- d. easy to translate into computer input; and
- e. easy adaptable to standard charts used in general practice.

The two-digit system was designed by Dr Jochen Vichl of Berlin who had used it for some years in conjunction with computer data handling. With this system the first digit designates the segment, digits 1 - 4 represent the permanent dentition and 5 - 8 to the deciduous dentition. The teeth are numbered the same as in the Palmer's Notation. The digits should be pronounced separately to avoid confusion with the Universal system, thus an upper right third molar is pronounced one-eight.

Permanent dentition

R	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	L
	48	47	46	45	44	43	32	41	31	32	33	34	35	36	37	38	

Deciduous dentition

R	55	54	53	52	51	61	62	63	64	65	L
	85	84	83	82	81	71	72	73	74	75	

The F.D.I. in numbering its segments, showed consideration for the next most common system the Universal system, the E.D.I. segments are numbered clockwise starting at the upper right and ending at the lower right. The F.D.I. realised that the two

digit system was a compromise, but it believed that this variant was the best solution.

4.4 The Designation of Surfaces

As well as tooth position being codified there are different designations for tooth surfaces in world usage, again the forensic odontologist should have a working knowledge of the various systems.

System A

The most common method is that of using the Latin root for the surface referred to, which is further coded to be the first letter of this word;

- m (mesial)
- o (occlusal)
- d (distal)
- l (lingual)
- i (incisal)
- b (buccal)
- (vestibular) (FDI)
- l (labial)

The main confusion arises with this system from the usage of buccal to refer to the surfaces of the molar and premolar teeth and labial to refer to same surfaces on anterior teeth. In the United States, France and Belgium the letter v (vestibular) is used to replace both buccal and labial, this is also the recommendation of the B.D.I.. In some countries 'l' (lingual) is subdivided with lingual used in the lower jaw and palatal for the teeth in the upper jaw. In the United States, Germany and Yugoslavia, 'li' is sometimes used to signify lingual.

System B.

Instead of using an alphabetical code to record surfaces, a numerical code is used in the United States.

- 1 (mesial)
- 2 (distal)
- 3 (buccal)
- 4 (lingual)
- 5 (occlusal)

A variation of this is found in Scandinavian countries with a different coding result.

- 1 (occlusal)
- 2 (mesial)
- 3 (facial)
- 4 (distal)
- 5 (lingual)

System C

In the United States and Britain the surfaces are sometimes recorded according to Black's classification, this however has been reduced significantly in usage over the last decade.

- Blacks Class I (occlusal)
 - II (proximal, premolar and molar regions)
 - III (proximal anterior)
 - IV (mesial)
 - V (gingival)

5. SPECIAL PROBLEMS ARISING IN DENTAL
IDENTIFICATION OF MASS DISASTER ACCIDENTS

5.1 Location of the Accident

5.1.1 Climatic considerations

The rate at which a body decomposes after death is governed primarily by the environmental temperature. A body in the humid heat of the tropics will not usually be identifiable after twenty four hours, whereas a body exposed in the snow covered regions may still be visually identifiable three months postmortem. The climatic conditions can influence considerably the type of examination carried out. The actual removal of bodies from a remote locale can take up to two days in itself; if the area is hot and humid the bodies would already be decomposing rapidly. In large airline crashes in remote areas, with few facilities for body storage, the bodies may be airlifted to another location for identification; as was the case with the Pan American 707 which crashed in Pago Pago in the Samoan Islands. Ninety unidentified bodies were taken to Los Angeles for identification. With the Danish Airline, Super Carouelle which crashed in a rugged mountain range near Dubai in the Persian Gulf, the temperature was 52°C in the shade. With little or not storage facilities the examinations had to be more rapid and not quite as detailed as would occur in mortuary with extensive storage facilities.

5.1.2 Distance from major centre

The majority of accidents occur within a four mile radius of the airport (ICAO Accident Manual). However a few aircraft disasters still occur in remote areas. Special dental identification kits, portable X-ray units together with a dental identification team should be ready at short notice to go for an extended period to an accident site. Therefore the members of a dental identification team should consist of members of the military dental corps or of State Health Commissions (private practitioners cannot leave their practices at short notice nor for lengthy periods).

5.1.3 Expertise of examining team; and the country in which the accident occurs

Although there are 110 national signatures to the ICAO Charter, not all nations have the technical experts to set up aircraft investigation groups as recommended in the ICAO Manual of Aircraft Accident Investigation. If an accident occurs in such a country dental teams may be sent by other contractory States to help in the investigation.

5.2 Antemortem dental records

The majority of people who travel by air have been of a social and financial standing that permits them to seek treatment in the event of dental illness (Keiser-Neilsen) (33) so there is a fairly good chance that most victims will have their dental

condition recorded somewhere. Possession of a dental record and obtaining and transporting it to the accident investigations are two different things.

The flight crew of most airlines (Australia being an exception) have dental records, dental X-rays and possibly oral photographs which are kept in a central medical records bank held by the airline. This enables fairly rapid identification of crew members, so that medical autopsies of the pilots can be carried out to see if there was any medical condition of the flight crew which may have caused the accident.

The ultimate responsibility for identification of disaster victims rests in most countries, with the police, who have to identify the body to the coroner. So in most instances the police carry out the collection of antemortem dental records from both relatives and dental practitioners. Part of any pre-disaster planning should be the education of the collecting agencies (the police) as to what is needed, ie the most complete and detailed dental information that can be provided with particular emphasis on antemortem dental X-rays. Dental charts, dental costs, old partial dentures, oral photographs from orthodontists or crown and bridge specialists should also be sought; even financial ledger cards may give useful information of the type of treatment given.

5.2.1 Collection of Antemortem dental records

The police should be thoroughly briefed on the importance of collection of a maximal amount of dental information. A standard format of questions that police should ask the relatives is as follows:

5.2.1.1 The names and addresses of all dental practitioners who had treated the victim (up-to-date address can usually be obtained from the State or Federal branches of the Dental Associations).

5.2.1.2 Did the victim have any dental insurance or, belong to a union dental plan or go for treatment to institutions such as a health centre, dental hospital, dental teaching establishments, or as a child go to the school dental nurse?

5.2.1.3 Was the victim ever in the armed services, or did he serve any National Service if so the branch of the service, rank, and serial number should be sought to help in the location of the records for the services Central Records bank.

5.2.1.4 Was the victim ever confined to a mental hospital or have a criminal record? Both these institutions may have dental records of the victim.

5.2.1.5 Do the relatives have any photographs which show the teeth of the victim? The relatives may also be able to describe specific dental characteristics of the victims, such as missing or discoloured teeth, gold crowns or prognathic jaw etc.

Once the names of victim's dentists are known by police, it is often helpful and time-saving for them to contact the State or Federal branches of the Dental Association who can verify the correct address of the victim's most current dentist and supply addresses of the other dentists who may have supplied previous treatment. With the increasing mobility of the community in the most developed countries of the world, it is quite common for a patient to be seen by two or three dentists in different states over a ten year period.

5.2.2 Difficulties with Dental Antemortem records

A person's dental state is usually recorded firstly on a diagrammatic chart depicting the entire dentition with the five surfaces of each tooth delineated. The dental work to be carried out is marked on the diagrammatic chart. Secondly the dentist writes notes on the treatment performed and the date of the treatment. These notes are usually recorded in a coded form using one of the tooth numbering systems of which there are over forty variations in the United States alone. Confusion arises from the variety of different systems and the identification of the one the dentists is using. Antemortem records are frequently inaccurate, incomplete or confusing. Ideally the dentist charts all pre-existing restorations and missing teeth, together with new work required. In the majority of cases the patient's original dental status had not been recorded, and only subsequent treatment has been recorded.

For example, to get a complete record for a fifty year old pilot; one may have to search through dental records up to 43 years old to find whether this patient had a lower first molar restored at the age of 7 years, the restoration being still intact and never subsequently recorded. This brings out the need for three things, firstly that police thoroughly check with relatives for names and addresses of all dentists who have treated the victims, secondly that all flight crew have their full dental record maintained at the airline central health records bank, and finally that every effort is made to locate dental X-rays which will usually clarify the situation in the event of incomplete dental charting on the antemortem dental records. 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.

5.2.3 Inaccuracies in antemortem records

.5.2.3.1 Impacted teeth

Impacted teeth which are not visible to the naked eye on examination, may be trapped between the roots of other teeth. This is especially common in the case of third molars which are last to erupt and often have no space left for them in which to erupt. Another tooth frequently impacted is the upper canine which is often horizontally impacted leaving the deciduous canine or canines in place.

The lower second premolar is also often impacted, but recorded on dental records, (as with the third molars and canines) as being absent. The unrecognised existence of impacted third molars may lead to a false conclusion that a victim is less than seventeen to twenty one years old, whereas the victim could actually be much older. Postmortem dental periapical X-rays of the lower third molar region are recommended in all cases where any lower natural teeth are in existence. This helps with both age estimation of victims, and positively identifies the second molar to be the second molar if the third molar is still in existence, but impacted.

5.2.3.2 Drifting of molars

If less than three molars are present in any segment, it is often difficult to distinguish them, especially if the occlusal surfaces have been mainly obliterated by a restoration or crown. A third molar is most often mistaken for a second molar which has been previously extracted allowing the third molar to erupt into the second molar space. This can also occur with the early extraction of both upper and lower first molars, the second molar can erupt and drift to occupy the first molar space and the third molar will subsequently occupy the second molar position. A careful study should also be made when only one premolar remains in a segment, first premolars are extracted for orthodontic reasons, but second premolars may also be extracted for similar reasons. Any dentist who is working in the field of forensic dentistry must therefore have a good knowledge of basic tooth morphology.

5.3 Identification of children

Children have less teeth than adults so the statistical chances of differences are reduced. In addition they have less dental treatment especially their deciduous dentitions. A further factor complicating identification is the increasing worldwide use of a fluoride supplement in water supplies, thereby making many children under eight years old, caries free. Further discussion of age estimation is seen in Chapter 3.

5.4 Identification of Asian nationals

Identification of Asian nationals presents a problem in identification by dental means, mainly because of a lower usage of dental facilities and therefore fewer antemortem records. Most Asians have low DMFT rates. These people present a special problem if they are a large number on one aircraft.

5.5 Edendulous Victims

In Britain in 1968 over 37% of the population of England and Wales, and in 1972, 44% of the population of Scotland over the age of 16 were denture wearers. The percentage in Australia and in the United States are only slightly less.

In modern aircraft accidents the hardest persons to identify are female full upper and full lower denture wearers. These women carry few personal documents near to their bodies and usually have no identifying marks in their dentures.

In the Turkish Airline disaster at Orly the majority of the 113 unidentified bodies were edentulous. Haines⁽²⁵⁾ reporting on 380 victims of air disasters of which 97 were edentulous, stated that the dentures of these individuals only have identification marks in 7 cases.

5.6 Denture Tagging

There is obviously a worldwide need to have a marking system for dentures. In many institutions such as dental hospitals, dental institutions and the armed services, of most countries, the marking of dentures is mandatory. The ideal requirements of an identity marking system as expounded by Pyke⁽⁵⁶⁾ are:

5.6.1 Bulk. It should not adversely affect the construction of the denture.

5.6.2 Method. It should be uncomplicated in both the method of inscription and of inclusion in the denture base during polymerization.

5.6.3 Aesthetics. It should be unobtrusive

5.6.4 Inertness. It should be able to resist intense heat (1000°C for three hours) and the action of solvents and acids.

A number of materials were examined by Pyke⁽⁵⁶⁾ including toughened paper, plastic strips, linen and nylon. All these were easily inscribed and included in the denture material, however, they were not indestructible.

The best alloy for indestructability to both heat and solvents was 'Ticonium', however this alloy was not available in strip form so the United Dental Hospital of Sydney used the next best alloy which was 'Brightray S' (comprising Ni 80% and Cr 20%). The strip was placed over the right molar diatoric chamber after the trial pack stage, this made the strip quite unobtrusive.

5.7 Denture marking

Many institutions use the patient's registration number together with a prefix letter identifying the hospital. The armed services in most countries use the member's regimental or service number. In English speaking countries there is not usually a national registration number, so private practitioners would have to use the surname and initials of the patient. There may be some objections to having a name on the dentures but the author thinks that the majority of patients will see the logic behind the inclusion, and its overall benefit to the patient.

5.8 Transmission of dental information

Various methods of telegraphic transmission of dental information have been devised, however as yet there has been no international standardization.

The best method of transmission of records is to send by express air freight the original antemortem dental records and X-rays. If, however, information is sent by telex, it is best not to use a code but to individually describe each tooth eg upper right first molar, has mesio-occlusal distal amalgam. With the greater usage of the F.D.I. system it may be possible in the future to use this tooth code for transmission.

Kaines⁽²³⁾ developed a code for telex transmission which was adopted by the RAF, but this code has an extremely limited usage.

5.8.1 Facsimile Transmission Equipment

This equipment in use in the United States can transmit accurate reproductions of all kinds of written material, even diagramatic charts can be transmitted in this fashion. The unit which is compact and light can be set up anywhere there is 100 volt power outlet and a telephone.

5.9 Computer coding systems

Recent computer models have shown that there are up to 2.5 billion possibilities in the charting of human teeth. Much effort is currently being expended on assessing the effectiveness of computerized dental charting in mass disaster identification. One such system devised by Haines⁽²⁴⁾ is the Premolar Classification System. This system is of use in smaller disasters (up to 100) but would be of little benefit in a large scale disaster.

In the case of a disaster involving 500 victims it would take one week to compare the charts of every victim with each of the antemortem charts of the 500 victims, assuming it takes 20 minutes to compare one chart with 500 others, (Cameron & Sims) (11). So that the use of a computer would be invaluable in such cases.

5.9.1 The premolar classification system of Haines (24)

Premolars are usually found intact after fires and do not suffer for such a degree of incorrect charting as do molar teeth. In this system the order of tooth examination is:

1. upper right second premolar.
2. upper left second premolar.
3. lower left second premolar.
4. lower right second premolar
5. upper right first premolar
6. upper left first premolar
7. lower left first premolar
8. lower right first premolar.

The second premolars are examined clockwise, and subsequently the first premolars are examined the same way. Then each premolar is given a number according to condition which is prefixed with M or F to show the sex of the patient. The condition is shown by the following code:

0. Deciduous tooth unerupted.
1. Unfilled deciduous tooth clinically visible.
2. Filled deciduous tooth cavity Class I or V.
3. Filled deciduous tooth cavity Class II.
4. Deciduous tooth extracted or shed, permanent tooth not yet erupted.
5. Unfilled permanent tooth clinically visible.
6. Filled permanent tooth cavity Class I or V.
7. Filled permanent tooth cavity Class II.
8. Permanent tooth extracted.
9. Prosthetic replacement tooth.

This system is far from being foolproof; it does not differentiate between mesio-occlusal, disto-occlusal and mesio-distal- occlusal restorations on the premolars, nor does it identify a tooth which may have more than one Class I or Class V cavity. This system is, however, a forerunner of many others whose feasibility is being studied. Computerization of dental records would establish records similar to that of finger-printing but could only work on a small scale as in an institutionalized population, such as the armed forces. Such a system would however, require massive backup to carry out the updating of all members of service's dental records and their subsequent dental state numbers. The computerization of the dental treatment records may be feasible but only for a limited population, who are receiving regular dental checks and constant upgrading of their dental state code numbering on to the computer.

6. FORENSIC DENTAL TEAMS - THEIR COMPOSITION AND ROLE

6.1 Introduction

In the 1950's and 1960's the worst civil aircraft disasters involved up to 150 victims. In many of these disasters the victims were buried in mass graves with little attempt at identification. A number of national forensic odontological groups were, however, set up to help rectify this situation. The first groups were in Norway, (Strom) (68) and in Denmark, (Keiser-Nielsen) (33). Later groups were set up in the United Kingdom at the RAF Institute of Pathology and Tropical Medicine, later again, groups were established in the United States and in Canada. The Canadian Society of Forensic Odontology had only been established for three days when it was called upon to help identify victims in the Air Canada DE-8 which crashed at Woodbridge, Ontario on July 5, 1970.

Since the introduction of the wide-bodied jumbo jets, the number killed in one accident could be up to 1,000 if two large jets had a mid-air collision over densely populated area. Recently at Tenerife, around 600 people were killed and subsequently badly burnt. With large groups of travellers now at risk it is not enough to have one or two forensic odontological experts on an investigating team; they would not be able to cope with the immense task of identification.

The aim of this chapter is to try to establish the size of the dental investigating team required to carry out oral autopsies and subsequent dental identifications on five hundred burnt victims, within a two week period.

6.2 Estimation of manpower required

To estimate the manpower needs, the average time taken for identification is required, Jakobsen, Keiser-Nielsen and Taldersbark⁽²⁸⁾ estimate that the oral autopsy with charting, X-rays and oral photography would take about 3 manhours (that is 1½ hours for a team of two examiners). Jakobsen's 'ideal' team of ten would examine about 25 bodies per day or about 150 per working week. After this period of six days the above authors suggest that a relief team be sent in. However, this three hours per body only covers the clinical examination, a further two hours per victim are required for the postmortem antemortem comparison studies and final identification. A great amount of time is required for comparisons; in fact the greater the number of victims the more complex the problem becomes.

If an average of five hours is required for an identification, then to investigate 500 bodies with a two week period would require about 27 dentists working six days a week, eight hours a day. Firstly I doubt if this would be humanly possible for all the team members, secondly, a team of about 30 people together with all the police experts, pathologists and

radiographers would logistically require a huge working and accommodation area. A group of well over 100 persons helping in identification together with up to 500 bodies would be an impossible situation unless an ice hockey rink could be found as it was in the Woodbridge disaster. The following is a synopsis of the composition of various national forensic dental groups.

6.2.1 Scandinavian team

The dental team at Hotel Hafnia fire in Copenhagen consisted of ten dentists. Eight dentists made up four examination teams who conducted visual examination and charting, the ninth member of the team took the X-rays and colour photographs which took less time than the visual charting so that the X-ray member was serving four examination groups. Colour photographs and X-rays were taken after the teeth and jaws had been exposed. The last member became the group leader, and was responsible for keeping a detailed record of procedures, and checking that all documents and films were attributed to the correct body.

6.2.2 The British team structure

There is an investigating team which is contracted to the major British airlines. This team comprises the coordinator or head of the team, a pathologist, a forensic odontologist, a specialist in jewellery, documents and an embalmer.

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the team consists of two groups, one which goes to the crash site and the other which collects information from the victim's dentist and doctor. Most sources consider this group too small to deal with a disaster of major proportions.

6.2.3 The American team structure

There are now forensic odontologists attached to most Coroners Courts in American cities. In some States forensic odontologists are very active and have organised teams of dentists with training programs for the groups. The Armed Forces Institute of Pathology runs a four-day training program for up to one hundred dentists interested in forensic dentistry.

6.2.4 The Australian team structure

In Australia there is as yet no Australasian society to act as a forum for forensic odontologists. The New South Wales Disaster Subcommittee has a forensic odontological working party, comprising the Deputy Adviser to the Health Minister on Dental Affairs, two of the NSW Regional Principle Dental Officers and the author of this thesis. This working party had decided on an eleven man team comprising dentists from the NSW Health Commission, and the Royal Australian Air Force. These dentists have volunteered and would be readily available should the need arise. The N.S.W. team would comprise four oral examination groups of two dentists each, and an X-ray team who would be taking two bitewing radiographs, and periapical

films of any anterior teeth that have been restored, together with periapical X-rays of the third molar regions. The medical radiographer, would be taking L and R oblique lateral films when he was carrying out the other full body X-rays. A Police photographer would work with the dental X-ray team taking colour pictures of the upper and lower jaws utilizing a front surfaced mirror.



Plate 3

Photograph of maxillary teeth utilizing a front surfaced mirror (Gustafson, G.).

The final or eleventh member of the NSW forensic dental team would be the team leader and coordinator.

6.3 The role of the Forensic Dental Team

The International Civil Aviation Organisation (ICAO) stated in Clause 26 of its charter that accidents occurring in a

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member's territory to aircraft registered elsewhere will be investigated in accordance with the ICAO Manual of Aircraft Accident Investigations. The country in which the crash occurs is responsible for the investigation, however the country of registration can send an accredited representative with additional advisors.

The following is a resume of items relevant to body identification taken from the ICAO Manual of Aircraft Accident Investigations, and also the Manual of Civil Aviation Medicine. Both of these publications are used in all countries who are signatories to the ICAO charter.

An ICAO signatory country in which an accident has occurred involving a foreign registered aircraft will carry out the investigation within the guidelines set out in the ICAO Manual of Aircraft Accident Investigation. An Investigator-in-Charge is appointed by the national government, this official has authority over the investigation and identification teams as they are inter-dependant, and is empowered to make sure there is no conflict of interest between the group investigating the structural components of the aircraft and those of the Human Factors Group who are dealing with the victims.

The Investigator-in-Charge would usually have had liaison with the police force during the planning stages. After the police and fire fighting services have rescued any survivors and extinguished the fire, the bodies of those killed

in the accident should be left in situ for examination and recording of the location of the victims, which may assist in their identification.

The Investigator-in-Charge will appoint a person to head the investigation into the structure of the aircraft and the circumstances leading up to the accident.

6.3.1 The Human Factors Groups

The Human Factors Groups may provide medical evidence which is of great value in relation to human engineering survival. The Investigator-in-Charge will appoint as head of the Human Factors Group a specialist in aviation medicine. In the event of fatalities a pathologist would also be appointed to carry out the autopsies.

6.3.2 Tasks at the Accident Site

Authorities differ on the tasks of the pathologist and leader of the forensic dental team at the accident. In the opinion of the Scandinavian forensic odontologists, forensic dentists should be available in sufficient numbers to assist the police and pathologist in the actual recovery of badly burnt bodies, (a dentist is more likely to recognise a burnt piece of mandible or teeth than is a policeman). Burnt bodies are likely to be mixed in with aircraft parts or building materials, and it takes specialist knowledge to be able to quickly identify remains of

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victims from that of fused plastic aircraft, cabin components etc. Again it is stressed that no specialist can operate without the assistance of all the others; this is especially true for forensic odontologists who must work in close cooperation with the police, who will be photographing, numbering and coding the relative positions of each body. It must be remembered that all groups should be working as a team towards a common goal; that of identifying the victims as rapidly as possible so that the bodies may be returned to their relations.

6.3.3 Recommendations of the International Criminal Police Organisation (INTERPOL)

The ICAO representative have modified the basic INTERPOL recommendations to cater for the different requirements following disasters with aircraft.

Firstly INTERPOL suggest that all bodies be photographed and numbered in their original position at the accident site.

The photographs provide a permanent visual record of the bodies' position relative to the aircraft and to other bodies in the vicinity. Bodies should be placed in temporary coffins (there are many types of plastic burial pouches available).

The recovery of bodies should be carried out with the help of specialists as referred to in earlier paragraphs. A major problem in modern aircraft accidents is to try to establish the guidelines as to what constitutes a body.

There is often a great degree of fragmentation of bodies in high speed aircraft accidents. In the Woodbridge Disaster⁽⁵⁵⁾ there were over 800 separate bags of human remains which comprised remains of the 109 victims. In the Turkish Airline disaster in the forest of Ermononville near Orly, the 346 bodies were fragmented into over 20,000 parts.⁽⁷¹⁾ Even after three months of attempted identification there were still 14 tons of fragments which could not be identified (Merritt, personal communication).⁽⁴⁷⁾ Stevens⁽⁶⁴⁾ is of the opinion that there should be two numbering systems for bodies, one system for remains which comprise more than half of a victim and a second system for the numbering of fragments. This method seems to have become accepted as the standard format for numbering bodies, in most accidents.

INTERPOL recommend that all clothing on the body should be transferred to the plastic body pouch with the body and transferred to the mortuary. It is stressed that great care should be taken so as not to place clothing or personal effects with a body to which it does not belong. An incorrectly assigned item could cause the identification team a great deal of additional work.

6.4 Team Work at the Mortuary

The following are different examples of procedures carried out at various aircraft accidents.

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6.4.1 Recommendation from ICAO Manual of Civil
Aviation Medicine

The ICAO recommendation is that the team comprising the pathologist, odontologist and other judicial authorities make a single joint examination of each body in turn. The pathologist usually selects the most readily identifiable bodies which are to be examined first. These are usually followed by whole bodies which are mutilated or burnt, and remains constituting more than half a body. The detailed examination of body fragments is undertaken last. The total number of human remains at the accident site usually bears no relationship to the number of passengers on the aircraft, as there is often severe fragmentation of the victims. The ICAO Manual recommends that a new and distinct series of numbers be used as cadaver numbers, so that when a body undergoes examination at the mortuary, the first thing that is done is to give it a number and then photograph it so that the remains show the cadaver and the site numbers. Clothing and Jewellery is then removed, examined and catalogued. These items are carefully examined for maker's marks and laundry marks. The body is then examined by the pathologist; when he has completed the external examination of the hands and head, the odontologist and finger-print expert should carry out their procedures. The final procedure being the examination by the pathologist of the cranial cavity,

0.125-0.75 0.015-0.15

The first thing I noticed when I stepped out of the car was the cold. It was a sharp, biting cold that seemed to seep into my bones. I shivered as I walked towards the entrance of the building, my hands tucked into my pockets. The air was thick with the scent of old wood and the faint, distant smell of coffee.

The building itself was a grand, old structure with a high, vaulted ceiling and walls made of dark, polished stone. The floor was covered in a thick, plush carpet that felt like walking on clouds. The lighting was soft and warm, coming from large, ornate chandeliers that hung from the ceiling.

As I walked through the hallways, I noticed several people. Some were dressed in formal attire, while others were in more casual clothing. They all seemed to be in a hurry, walking quickly and looking down at their phones or papers. I felt a bit out of place among them, but I didn't say anything.

The office I was in was on the top floor. It was a large, open-plan office with several desks and computers. The walls were covered in bookshelves filled with books. The air was filled with the sound of keyboards and the hum of computers. I sat at my desk, which was cluttered with papers and a small potted plant.

The first few days were a blur. I was overwhelmed by the amount of work I had to do. I had to learn a lot of new things, and I had to do it all in a very short amount of time. But I didn't let that stop me. I worked hard, and I did my best.

One day, I was sitting at my desk, looking at a document. I noticed a small, white envelope sitting on the desk next to me. I picked it up and opened it. Inside, I found a letter from my mother. It was a letter I had never received before. I read it slowly, and I felt a lump in my throat.

The letter was from my mother, and it was dated the day I had left home. It was a letter of love and support, and it was exactly what I needed. I read it over and over again, and I felt a sense of peace.

After that, everything seemed to fall into place. I knew what I was doing, and I knew where I was going. I was no longer a stranger in a strange land. I was home.

The first of these is the fact that the
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all joint examinations on all whole bodies and remains constituting more than half a body are completed, the fragments are then examined. The possibility of important evidence with regard to the accident investigation itself being present in a dismembered part of a body must not be overlooked. Commonly the examination of fragments will be of most value with regard to the final count of victims and with regard to the individual identification of a major fragment. Clues to identify that may be on an extremity could help to identify the whole body if the fragments can be associated by anatomic comparison.

Individual bodies should not be released until all investigation and identifications are complete with respect to the accident as a whole.

6.4.2 Procedures adopted at Woodbridge Disaster,
July, 1970

Pownall and Purves et al carried out the dental autopsies on the victims of the Air Canada DC-8 crash at Woodbridge on July 5, 1970. This crash occurred only three days after Doctor's Pownall and Purves formed the Canadian Society of Forensic Odontology.

With high speed impact aircraft accidents, there is usually very little destruction by fire, but there is a great deal of fragmentation of victims.

In the Orly disaster of 1974 there were 20,000 fragments from 346 bodies. In the Woodbridge accident there were over 800 bags of human remains which comprised bodies of the 109 victims. At Woodbridge there was gross destruction of the middle third of the face, with most of the bone structure of the middle third being lost leaving only the top of the cranium and the mandible attached by soft tissue. The mandibular fragments were often still attached to the body which was thrown out of the aircraft whereas maxillas were found near the crash crater. The collection of bodies was carried out by the Canadian police as per the ICAO procedures, with the remains being numbered and photographed, and given a reference point in accordance with the grid system established at the site. The bodies were transferred to an ice hockey rink floor where the victims were stored in large open boxes on the ice. This open plan approach is extremely useful where there are so many fragments it makes anatomical comparisons much easier. An autopsy any dental specimens removed from the body, were labelled and cleaned. Then details of the specimen were recorded including a description on the size of the fragment together with any characteristic features such as rotations, diastemas and hypo and hyperplasias. Restorations were recorded (as the position size and shape) on an odontogram. X-rays together with colour photographs were taken of all the specimens to form a permanent record.

The dental teams tried to use a punch card system to help in elimination, however because of the great number of fragments and difficulty in standardising the programming, it was not successful. Elimination charts were similarly of little use. The group standardised the antemortem records and then each postmortem X-ray with its matching colour slide was compared with all antemortem dental data. This method was most time consuming but may, in effect, be the only successful method of identification when there are many body fragments.

Antemortem dental records could only be collected for 67 out of the 109 passengers, however, dental identification was made in 72% of cases where antemortem dental records were available. In all, 53 victims were identified solely by dental methods. This was 60% of all identifications. Corroborative dental evidence made a significant contribution in the identification of many other victims.

6.4.3 Procedures adopted at two aircraft accidents (58) in the United States, as reported by Salley et al

The first case was that of a turbojet airliner which crashed and burned near Holdcroft on January 18, 1960 with the loss of 50 lives. In the second accident on November 8, 1961, a chartered commercial airliner crashed killing 77 army recruits. After both these accidents the bodies were numbered and placed in plastic pouches, after being given a grid reference position in the aircraft.

Both the above accidents were probably accidents occurring at a much lower speed than did the Woodbridge accident, there was much more burning of bodies but not as much fragmentation as at Woodbridge. Basically, there are two types of accidents; the high speed crash with a great amount of fragmentation of bodies but little burning, and secondly, accidents on landing or take-off at speeds of below 150 knots where there is little dismemberment of aircraft or victims but the accident is usually subject to conflagration. In the Holdcroft accident severe incineration and heat fixation of tissues resulted in surgical incisions being necessary to give access to the mouth. Half of the victims had sustained prolonged burning which had destroyed the anterior segments of both the mandible and the maxilla, however few bodies had complete destruction of their heads. After surgical exposure the debris was removed from the teeth and a record was taken. Missing teeth were marked as absent either postmortem or antemortem. In review of post and antemortem records, association were facilitated by matching tooth extraction patterns. In some instances where severe burning had destroyed all but one segment of the jaws, including charring of the teeth, antemortem extraction patterns represented the primary means of dental identification. Even with severe charring enough points of concordance can be gained, in most cases, from a combination of extraction positions and restorations.

The dental evidence in the last ten victims of the second accident, was too patchy to make positive identification. Again the team approach is required with a system of eliminations using dental and medical findings in association with personal effects which may have been found near the body. Cooperation between dental and medical experts is essential so that final identifications on difficult cases can evolve by negative and positive medical and dental findings.

In the first accident 13 of the 17 persons for whom there were adequate antemortem dental records, were identified. In the accident with army recruits 49 of the 77 victims were identified from dental records.

When comparing the civilian accident with the military accident, greater numbers of the military crash victims are identified by dental methods than in the corresponding civil crash.

Military personnel have antemortem dental records which are usually accurate, up-to-date, and centrally located. The effectiveness of a dental identification is firstly related to the recovery and recording of remains. But of just as great importance is the availability of antemortem dental records which are accurate and up-to-date or include dental radiographs. Without antemortem records one is left with the relatives' recollection of the victim's dentition.

From the foregoing discussion, the need for an established dental team who have been trained as a group, emerges.

7. ORAL AUTOPSY TECHNIQUES AND DENTAL
IDENTIFICATION KITS

7.1 Oral Autopsy techniques

Where there are no apparent injuries or decomposition of the facial features, every attempt should be made to disturb the facial features as little as possible. Any body which has its facial features reasonably unmutilated should be photographed as soon as possible.

In a mass disaster situation, the body may not be identified by relations because of the distances involved, however the forensic team could identify the body from antemortem photographs of the victim. After the body has been photographed a dental examination should be carried out, including X-rays and oral photographs. If, however, rigor mortis has set in and oral access is impossible, a technique devised by Jakobsen et al⁽²⁸⁾ creates oral access with minimal change in facial expression.

7.1.1 The Horseshoe incision technique

This technique involves a horseshow shaped incision from one angle of the mandible to the other, some 5 cms below the base. Dissection is then carried out to the base of the mandible with subsequent dissection off the mandible of the insertions of the digastrin, massatur and mediall pterygaid muscles, together with those of the muscles of facial expression.

This will loosen a facial tissue flap which can be drawn upwards giving access to the teeth as well as being able to open the mouth. The mobile flap of tissue can later be restored into its original position and sutured; leaving little change in facial expression.

In severe cases of burning there is no chance of visual identification of the victim by relatives; a more direct surgical approach can be made to gain access to the oral structures.

7.1.2 Rectangular section

Rectangular section as proposed by Keiser-Nielsen⁽³⁴⁾ advocated the removal of a rectangular area of the cheeks including the lips, down to the bottom of all sulcii, in order to expose the labial surfaces of the teeth. Further surgical intervention may be necessary below the mandibular base to be able to move the mandible downwards and gain access to occlusal and lingual surfaces of the teeth. When the oral autopsy is completed the removed tissue can be restored in position with transparent adhesive tape.

7.1.3 Resection technique as per Lunta and Lunta⁽⁴¹⁾

The final method is the most commonly used method in case of facial burning. This technique can be used to gain access to the teeth with disarticulation or if carried out further the jaws can be completely resected.

Two incisions are made on each side of the face, these incision lines form a V and are started at the commissure of the mouth and extended to the angle of the mandible. The tissue is then dissected from the mandible exposing the ramus. Then using a reciprocating autopsy saw, bilateral horizontal saw cuts are made through the ramii to allow removal of the lower portion of the mandible. The mandible need not be fully removed, this method provides access to the mouth by disarticulating the jaws. Disarticulation may also be achieved by exposure of the condyle and cutting of the bones below the head of the condyle - however this is more time consuming and the previous method is in more frequent useage.

The removal of the maxilla, is achieved by firstly removing the tissue covering the maxilla then a saw cut is made above the apical areas of the maxillary teeth. The maxilla can then be disengaged from the skull with the help of a large bone chisel.

If the jaws are to be kept for teaching purposes, as much soft tissue as possible should be surgically removed.

Remaining soft tissue can be dissolved by placing the jaws in a strong solution of caustic soda (sodium hydroxide).

After soaking for two days the jaws can be thoroughly washed and dried; they can now be kept in the dry state.

7.2 Equipment for Oral Autopsies

7.2.1 Radiographic Equipment

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Most mortuaries will not have any dental X-ray machines. For this reason the forensic dental team should have available at short notice a portable machine for postmortem examinations. The machines most commonly used would be, in Europe and Australasia, Phillips portable Oralix and in the United States a Min-X-Ray. The Min-X-Ray which is the more portable and lighter of the two, operates on 110-130 volts 60 cycle AC power where the Phillip Oralix comes in either 240 volt 50 cycles AC or 110-130 volt with 60 cycle.

7.2.1.1 Portable X-ray Units

The "Bendix"- Ray Model 105" weighs less than 7 kg and can operate on either 110 or 240 volts or battery systems. It has a built in aluminium filter and a dose rate per pulse of one millirontgen at 30 cms. Because of its low weight and size together with its ability to be run off batteries this unit can be used in cases of accidents in remote areas.

Another portable unit which has been used with success by the Swedes is the Iodine - 125 X-ray Unit. The radioactive source with its container is only the size of ballpoint pen. The unit was constructed by Beranius, Forberg, Kenrikson and Soremarm⁽²⁶⁾ in 1962, the radioactive source is deposited on a piece of silver wire. It is shielded by gold foil 1mm thick; the shield is constructed so that it is removed by a simple mechanical mechanism without subjecting the operation to any radioactive exposure. This unit is unfortunately very expensive to reactivate.

It can be used in conjunction with a self developing X-ray film which eliminates the need for a developing kit and was used with success at the Super Caravelle accident at Dubai in 1972.

7.2.1.2 Panoramic X-ray units

Panoramic X-ray units take a long narrow film showing the lower half of the face including the maxillary teeth and jaws. A disadvantage of the use of this unit for forensic dental purposes is that the jaws must either be resected from the corpse or the operator must be dealing with a skeleton. The United States Air Force is, however, using a panoramic X-ray together with initial dental chartings, as their identification cornerstone for recruits, (Duckmanton) (13). This method of recording is quick and covers a broad span, but it is difficult to reproduce the same result when trying to identify a corpse. If self developing dental radiograph film is used then there is not need for a dark room facilities. However, the availability of films such as Phip-X-30 may be limited in many parts of the world, so it is preferable for the forensic odontological team to have access to a light-weight self-contained developing unit such as a "Prilomat" which does not require dark room facilities which, in a marque may be already overextended, processing larger medical films.

7.2.2 Photographic Equipment and Registration

Much of the analysis of the benefits and methods of photographic

registration of persons was carried out by Johanson and Linderstrom.⁽³⁰⁾ They used special mirrors which were front surfaced to eliminate the double reflection (which results with the use of glass mirrors). A single lens reflex camera, with an electronic ring flash which had an effective light duration of 1/6000th sec was used. The large front surfaced mirrors allow the inclusion of most surfaces of the upper or lower jaw in one photograph. The labial surface is taken by direct vision and the occlusal and lingual by reflection in the mirror. There are usually a series of three colour photographs taken, one a full face of the person with a registration number and then two oral photographs also both in colour. These photographs are a quick method of mass registration of persons especially those in the community at risk, such as airline flight crews, divers and explosives experts. The photographic record is universally understood without any written description.



Plate 4

Registration photograph of airline personnel incorporating intraoral photographs (Gustafson) G.).

7.2.3 Basic Dental Identification kits

Accidents requiring the services of forensic odontologists can occur at any time. A complete set of identification equipment should be kept permanently prepared for each team in the forensic dental group. The X-ray teams should know where their portable X-ray units are and where the self-contained

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developing machine can be located. This group should also be able to obtain, at short notice, up to two thousand of the 'long' bitewing dental films together with four hundred periapical films (all of which should be within their expiry dates). The kits should be checked periodically to replace any perished or time-expired equipment. The team should strive to be as self contained as possible, and plan for the worst possible set of circumstances.

The following is a combination of kits recommended by Lunta and Luntz⁽⁴²⁾ and that of Ford and Ashley⁽¹⁴⁾ of the RAF.

Dental mouth mirrors	16	front surface
Dental explorers, assorted	6	
Ferguson mouth gag	1	
Rubber props	3	
Scalpels	5	
Scalpel blades, assorted	10	
Hemostats, assorted	3	
Surgical scissors, assorted	3	
Surgical bone saw or		
Stryker autopsy saw	1	
Headlight	1	
Dental diagnostic flashlight	1	
Gauze pads	4	packages
Dye disclosing solution	1	(merthiuolate, to show sili-
Cotton rolls	6	cates etc
Noxema (optional)	1	package
Face masks	1	
Rubber gloves, assorted	6	pairs
Rubber gloves, heavy	3	pairs
Aprons	5	
Toothbrushes	4	
Extension dord, heavy duty	1	
Pens and pencils	6	
Clipboards	2	
Examination charts	6	
Ruler, inch and metric	2	
Photographic and radiographic material		
Plastic bags	1	
Osteotome	1	
Mallet	1	
1 Phillips Dralea X-ray unit		
1 Prilomat X-ray film developer.		

TABLE II DENTAL IDENTIFICATION KIT

7.2.3.1 Instruments for dental examination

Mouth mirrors and explorers. At least five non-disposable mouth mirrors, with a front surface reflecting mirror, together with a similar number of sickle shaped probes. (No. 23).

Scalpels, Haemostats, Scissors. Disposable scalpels tend to break frequently when cutting thick burnt tissue, stainless steel handled scalpels are best, with two dozen No. 20 blades. Two Spencer Wells haemostats are useful for retraction and holding of tissue; these are often used in conjunction with a pair of straight bladed surgical scissors about 15 cms long.

Headlamp and dental diagnostic mirror. In most mortuary situations the lighting may be adequate for the pathologist but it usually is not of sufficient intensity nor is it capable of being manoeuvred adequately, to illuminate the oral cavity. A portable battery-powered head lamp will provide adequate lighting for several hours. Many brands are available of both battery and mains powered varieties. A small dental diagnostic flashlight is also of value in searching for teeth lodged in the throats of the victims.

7.2.3.2 Cleaning Materials

Cleaning of the teeth of burnt tissue and debris is essential before recording the dental state of the body. Two tooth-brushes, a nail brush, a Hunts syringe and gauze pads should be included in each kit.

7.2.3.2 Cleaning Materials

Cleaning of the teeth of burnt tissue and debris is essential before recording the dental state of the body. Two toothbrushes a nail brush, a Hunt's syringe and gauze pads should be included in each kit.

7.3.2.3 Protective Clothing

Six pairs of surgical gloves or three pairs of a heavier duty type gloves should be provided, also gowns or disposable plastic aprons. Other protective clothing should include a pair of rubber boots for each team member and disposable face masks with a bottle of "Noxzenia" or similar odour suppressent.

7.3.2.4 Instruments for exposing or removing jaws

A reciprocating bone saw is usually available in most mortuaries, however a short surgical saw together with an osteotome and mallet should be included in the kit. A Ferguson mouth gag and a set of mouth props together with some disclosing dye (merthiolate to show silicates and composite restoration) are also recommended.

7.2.3.5 Recording Materials

In addition to the obvious such as pens and odontograms, a ruler (in inches and cms), a Kodak colour strip and plastic bags for holding specimens are necessary.

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[The following text is extremely faint and largely illegible due to the quality of the scan. It appears to be a list or index of items, possibly related to the Department of the History of Arts and Architecture at the University of Chicago. The text is organized into several columns and rows, but the specific details are not discernible.]

7.2.3.6 Carrying Case

A strong but light weight carrying case with internal divisions for the various groups of equipment is required. An aluminium or light-weight stainless steel cabinet is ideal. The RAF kit has strong carrying handles and a shoulder strap but also converts into a working cabinet when placed on its side.

8. CONTROLLING AGENCIES IN RELATION TO MASS

DISASTERS IN NEW SOUTH WALES

8.1 Federal Department of Transport

The Air Navigation Regulations have yet to be amended and still refer to the Director General of Civil Aviation and not to the Department of Transport. However, Regulation 272 refers to the particulars required in a report on an aircraft accident as follows :

- a. the type, nationality and registration marks of the aircraft;
- b. the name of the owner, operator and hirer (if any) of the aircraft;
- c. the name of the pilot in command of the aircraft;
- d. the date and time when the accident occurred;
- e. the last point of departure and the point of intended landing of the aircraft and the nature of the flight;
- f. the location of the accident with reference to some easily defined geographical point;
- g. the number of persons killed (if any) and the number seriously injured, and where possible, the names of such persons;
- h. the nature and cause of the accident as far as is known, and
- i. the nature and extent of damage to the aircraft.

REPORT OF THE COMMISSIONER OF THE GENERAL LAND OFFICE

FOR THE YEAR 1897

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Regulation 273 states that if the accident has occurred to an aircraft registered in one of ICAO contracting states, then the Director General will supply particulars of the report to the contracting country. Further to this, Regulation 284 states that the Board of Accident Investigation will be furnished with relevant information by the contracting states, on the registered aircraft, and serving log book. The contracting state may appoint an accredited representative, who may be accompanied by technical and other advisors, to take part in all, or any part of the investigation conducted in Australian territory. Further the Director General may delegate any part of the investigation to an investigator appointed by the country of registration, and, in relation to any part of the investigation so delegated, the investigator appointed as in Regulation 278.

Custody, protection and removal of aircraft; where an accident occurs to an aircraft in Australian territory, the aircraft has been deemed to be in custody of the Director General of Civil Aviation and shall not be removed or interfered with except with the action necessary for:

- a. the extrication of persons, animals and mails from the wreckage of an aircraft;
- b. the protection of the wreckage from destruction by fire or other cause;
- c. the prevention of danger, or removal of obstruction, to air navigation, to other transport or to the public;

- d. the removal of the aircraft and its contents to a place of safety when the aircraft is wrecked on water; or
- e. the removal of goods or baggage under the supervision of a constable, but in the case of an aircraft which has come from outside Australian territory the goods or baggage shall not be removed from the vicinity of the aircraft except on a clearance by, or with the consent of, an officer of Customs.

The Department of Transport (DOT) in conjunction with the New South Wales Fire Brigade will be responsible for fire fighting at the accident scene.

8.2 The N.S.W. Police Commission

The DOT has agreed that the NSW Police Commission be the coordinating authority at the disaster scene and be responsible for:

- a. Rescue of survivors.
- b. Guarding of wreckage.
- c. Location of bodies and their identification.

The Police communications centre, on receipt of a message that an air disaster has occurred or is imminent, contacts the relevant police authorities including the Emergency Officer Group which would proceed to the disaster scene and set up a command post..

All communication in and out on victim identification will emanate from the command post. The Airline whose aircraft is involved will supply the command post with a passenger manifest. The Disaster Victim Identification Unit (DVI team) from the Criminal Investigation Bureau headed by Inspector Merrit, is controlled from the command centre and will try to locate bodies in the wreckage. After victims have been certified dead by the medical team, the DVI team will then record the location of the body with reference to positional grid for the accident. The body is given an identification number on an aluminium tag and then photographed so that the tag number is showing. The body is then taken to a body assessment area where the clothing and personal effects of the body are recorded on the Interpol DVI form. The body is then transported to either the City Morgue at Glebe or hired coolroom depending on the numbers of victims and the degree of fragmentation of bodies. If the accident occurs in a remote locale the bodies will be transferred to the Sydney City Morgue in refrigerated trucks.

8.3 N.S.W. Health Commission

At the morgue the Human Factors Group, with the aviation pathologist in charge of the group, will remove and record all clothing, personal effects and jewellery. The pathologist will then try to establish the cause of death and record any identifying medical pathology, the body will be finger-printed

and an oral autopsy will be carried out by the forensic dental team at this stage. All information is recorded on the Interpol Disaster Victim Identification form (DIV form). The odontogram of the DIV form does not have space for remarks on each tooth, such as restorative materials used etc. The N.S.W. Health Commission has modified the Interpol odontogram and will carry out the oral charting on separate sheets which will be attached to the odontogram.

8.4 N.S.W. Disaster Subcommittee

The New South Wales Government has a Disaster Subcommittee which is chaired by the Chief Government Forensic Pathologist. The Committee comprises representatives from the N.S.W Police Force, the Federal Department of Transport, the Airlines and a forensic odontologist from the N.S.W. Health Commission, Dr. John Wild. The Disaster Subcommittee empowered Dr. Wild to form a working party to plan a Dental Disaster team. The working party consists of Dr. Wild, two of the regional Principal Dental Officers and the author. The N.S.W. dental team is to comprise dentists from the various regional dental services who are all employed by the Health Commission and so would be readily available at short notice, and for extended periods. The basic team is to be of eleven dentists, but may call on forensic odontologists from the armed forces. A further backup team of ten dentists would be trained to alternate with the first team every five days or so.

When all the members of various groups helping identification have come to an agreement on the identity of a body, then the central command post is informed, the command post then notifies the next of kin of the identification of the body. The police have to, at a later stage, give the reasons for identification to the Coroner in whose district the crash has taken place.

8.5 The State Emergency Service

The State Emergency Service is constituted under the State Emergency Service and Civil Defence Act of 1972 which gives the NSW Government Minister for Services and the Governor of NSW the right to invoke the Act and declare a state of emergency for a seven day period, to be reviewed every seven days. This Act has never been invoked but it would give the Director of the State Emergency Services the complete coordinating control over all State Government employees including the Police. In most cases the Act will never be invoked, but the State Emergency Service can be called in by the police but would still work under the overall coordination of the NSW Police Force.

8.6 The Airlines

The Airlines have to supply the police command centre with a passenger manifest, however the police are loathe to have the

Airline initiating any collection of antemortem dental records.

The Interpol Disaster Victims Identification Form (DVI) is used in most aircraft disasters in Europe and Australasia.

Two copies are raised, on the first form is recorded the particulars of the unknown body with its postmortem dental charting and medical and dental X-rays.

A further copy is raised, one for each of the passengers on the manifest. In the Orly disaster the second copy of the form was sent to the victims embassy and then, many were posted from the embassys to the next of kin. Only one third of the forms were returned fully completed. Some nations were more careful than others, with the Japanese police carrying out the most meticulous enquiries.

The mailing of the DVI form to next of kin is both insensitive and ineffective. Specially trained police are available, in most developed countries, who are experienced in gaining the relevant information from next of kin eg. type of clothing being worn by victim, address of doctor and all known dentists who have treated the victims; and whether or not the victim had had any previous military service.

The police should liaise with either the State or Federal Branches of the Dental Associations to gain records and addresses of dentists who have treated the victim. The dental association can greatly assist the police in confirmation of addresses of dentists, and the actual location of a dentist,

when either the dentist has moved or next of kin do not know the dentist's address. The associations in the majority of cases would be willing to contact the dentists involved so that the dentist could compile all relevant documents and so reduce the police time in collection of documents. By collection of antemortem records as soon after the accident as possible, reduces the overall time it takes to match the two copies of the DVI form and hence return a relation for burial as soon as humanly possible.

9. SUMMARY

Teeth, on exposure to postmortem influences will outlast all other body tissues. The materials used to restore damaged teeth are also extremely resistant to both physical and chemical destruction. Because of these properties, teeth become a valuable method of identifying victims when visual identification is not possible. Identification on the basis of a person's dental state, is of most benefit in cases of burning of a victim or of nationals who have no antemortem finger-print record.

Identification of bodies is necessary for two main reasons, firstly so that the body can be returned to the relatives for burial (which holds special religious significance in many instances), and secondly so that a death certificate can be issued, without which there can be no finalization of the estates nor can the spouse remarry.

The majority of disasters, where bodies cannot be visually recognised, occur as a result of aviation accidents. The advent of the jumbo jets which can carry over four hundred passengers, together with the high degree of internationalism of passengers even in national flag carrying airlines, create enormous problems in identification in the event of an accident and subsequent burning of the aircraft. There are two major types of aircraft accidents. Firstly, there is the high speed accident, an accident at over 200 knots,

usually occurring after either structural failure of the aircraft, or the misreading of altimeters and the subsequent crash into high terrain at cruising speeds. This first type of accident creates the greatest problems in identification. In these accidents there is usually very little burning of either the aircraft or the bodies, however there is a great degree of body fragmentation, over 20,000 fragments from 370 bodies in the Turkish Airlines DC10 disaster⁽⁷¹⁾ at Orly. The fragments are often very small and can only infrequently be matched by anatomic comparison (over fourteen tons of body fragments remained unidentified in the French morgue, three months after the Turkish disaster).⁽⁴⁷⁾ Identification in this type of accident is a long and tedious procedure with fairly equal emphasis being placed on identification by dental state, fingerprints, documents and jewellery. The second type of accident occurs at much lower speeds, usually in the region of 150 knots. These accidents comprise over three quarters of aircraft accidents and usually occur within ten miles of the airport boundaries. The aircraft is either in landing or taking off configuration, and the accidents are caused by under or overshooting the runway, or by wind sheer and subsequent stall of the aircraft. Crashing at lower speeds, the aircraft remains basically intact but fuel from ruptured tanks spilling on hot engines creates an almost immediate conflagration. In this type of accident, dental identification can play the major role.

The victims have been burnt so that both visual identification and finger-printing are often excluded as is identification from documentation.

In aircraft accidents in the 1960's a few highly trained experts could identify the twenty or thirty victims. With the numbers of victims killed in recent accidents, teams of experts including forensic dental teams should be trained to carry out up to five hundred oral autopsies within a two week period. Such teams have to be trained prior to any accident to gain the expertise needed for such a task. Two teams comprising eleven dentists each, are currently being formed from members of the NSW Health Commission and the Armed Forces, and it is hoped that these teams will undergo a training program in the near future.

The major problem in identification by dental means is in the finding and transmission of antemortem dental records to the accident site. The present procedure used by the NSW Police Commission uses the Interpol Disaster Victim Identification Form (DVI Form). Two copies of the form are used for each victim. One copy is used at the morgue for recording details of the victims, clothing, dental record and conditions of medical significance. The second form contains basic particulars of all passengers on the airline passenger manifest. This form is sent to the victim's local embassy, from whence it is usually sent by mail to the next of kin. This method is unsatisfactory with only one third of the DVI forms being

returned after the Turkish Airlines disaster at Orly.

A more effective worldwide method of transmission of dental records must be designed, including a combined approach involving both the police and also staff of the national and state Dental Association.

In the Canadian Woodbridge disaster⁽⁵⁵⁾ it was shown that elimination charts are of little value when there are over one hundred casualties. A system will have to be devised on a similar pattern to that of the Haines premolar system⁽²⁴⁾: In the Haines system using only the first and second premolars, the victim's dental state for those teeth is given a combination of eight numbers representing the eight premolars, with a dental state code from 0 to 9 for each tooth. To increase the numbers of combinations this system may have to be expanded. However under the Haines system or a similar improved version, the antemortem and postmortem dental states could be placed on computer disc and the computer could be programmed to record matching or near matching pairs of records. A system such as this would be of benefit in the second type of aircraft accident, but in the first type, where there is severe fragmentation, there seems to be no easy way; but that of direct comparison of all fragments to all antemortem records, which could take up to three months to complete.

While circumstantial evidence, in the form of clothing and documents may help in identification, the safest data to rely on are physical features on the body itself. Physical features that do not vary throughout life are finger-prints. In finger-print matching, a minimum of twelve concordant characteristics form a positive comparison. Keiser-Nielsen⁽³²⁾ states that twelve concordant dental features should be found for positive identification, however, with fragmentation of skulls this is not always possible. A fixed dental bridge on comparison of the antemortem and postmortem X-rays may be considered by the dentist to be proof enough. It is the privilege of an expert to provide this professional opinion on a matter; if all facts could be established on strictly scientific evidence there would be little need to have forensic experts. So dental identification in many instances may be the professional opinion of an expert dental witness, as Soren Keiser-Nielsen states 'I very much fear that dental identification can never become an exact science' (personal communication).

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