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FORENSIC DENTISTRY
IDENTIFICATION THROUGH DENTAL CHARACTERISTICS
AND ITS APPLICATION TO THE MALAYSIAN ARMED FORCES

BASURI bin FAKI

BDS (University of Malaya, Malaysia 1983)

A thesis submitted in partial requirement for the
DIPLOMA IN PUBLIC HEALTH DENTISTRY

Department of Preventive Dentistry
Faculty of Dentistry
University of Sydney

1991
SUMMARY

It is something of a paradox that teeth can be destroyed relatively rapid in vivo and yet are almost indestructible post-mortem (Newbrun 1978). Teeth on exposure to post-mortem influences will outlast other body tissues. The materials used to restore damaged teeth are, as well, extremely resistant to physical, chemical and biological destruction. Thus, teeth become a valuable method of identifying victims when other methods are not possible and in victims of burns or persons with no fingerprint record, dental identification is most beneficial.

The scope of forensic dentistry is broad; it encompasses the general disciplines of dentistry. The identification of remains through dental characteristics requires substantial knowledge of dentistry and interaction with other various fields of forensic specialty. Forensic dentistry is that branch of dentistry which, in the interest of the law, deals with the proper handling and examination of the dental evidence and the proper evaluation and presentation of such evidence (Keiser-Nielsen 1967 cited by Harvey 1976).

The science of forensic dentistry is basically confined to the cranio-facial structures. The teeth and its dental restorations, dental prostheses, the pattern of bony trabeculae and its protuberances, configuration of the air sinuses and the overall oral facial morphology present a vast number of variation of possibilities and information. The ability to recognise, gather, preserve, organise, document and present such information is the heart of forensic dentistry. It may be possible by observation or by radiographic techniques for the dental forensic expert to give an opinion as to the age, occupation or habits of the person involved and the previous medical history of a person who has received regular dental treatment.

Identification procedures are mainly:

a. Collection and recording of post-mortem data of unknown bodies.
b. Collection and recording of ante-mortem data of persons reported missing.
c. Comparing post-mortem data and ante-mortem data.
d. Completion of a report on the outcome of the comparison.

(Keiser-Nielsen 1980)
Forensic dentistry can basically be divided into 3 major fields; civil - non criminal, criminal, and research/teaching. The need for identification is basically for legal, criminal, humanitarian and research/assessment purposes. Forensic dentistry has played an important role in the legal and social issues that arises from natural and man-made disasters when death occurs. Various methods of identification have been used and they can be divided into scientific and non-scientific methods. Fingerprints and dental examination rate among the most reliable scientific methods of identification.

There are over 100 different methods of charting worldwide. The failure of the international dental community to accept and acknowledge the advantage of a single system can only be a reflection of their perversity. Inevitably, the choice of dental chart will be that in current usage in the country concerned. Dental records of all patients are important documents, for they may assume considerable dento-legal importance.

Identification is a result of reasoning and logic; it involves evaluating the quantitative and qualitative similarities and congruence of the post-mortem and ante-mortem dental data. **Computers** help to facilitate the sorting, retrieval and analysis of the data but they are only a sorting tool and **not a method to identify victims positively**. Computer matching does not obviate the need for ante-mortem and post-mortem dental record examination and final identification by a forensic dentist, since forensic dental reports and statements are based upon professional skill.

Problems encountered during the course of identifying human remains are discussed. The use of different tooth designation systems is an example of charting-related problems. The nature of the ante-mortem dental records such as their illegibility, lack of adequate charting and inadequate dental radiographs (quality, orientation and dating) or refusal of dentists to cooperate in releasing dental records attribute to the identification process problems. The 'pinking' of teeth after death must be differentiated from pink teeth ante-mortem. Fragmentation of the dental evidence as a result of high speed collision or bombings, and identification after fire are discussed.
The problem of identifying human remains has been, and continues to be, a problem facing the military. Armed conflict produces mass casualties of whom many are mutilated, and remains may be fragmented or burned beyond recognition. Occasionally, bodies or remains of soldiers are returned to their country of origin from the area of conflict many years following the conflicts. One doctrine of forensic science states that all skeletal remains should be treated as commingling. One must also attempt not to accept as fact the tentative identification provided by any source when the origin of the material is questionable or the chain of evidence has been broken (Dailey 1987).

The value of preparing and retaining comprehensive military records has been repeatedly shown. A review of the literature illustrates the importance and value of updated dental records in the identification of service personnel killed during wars. It is essential that a separate record is filed, kept up to date and stored in a 'safe' place away from the place of service. It is acknowledged, that in the turmoil of conflict such a safe place may be compromised.

The Malaysian Armed Forces (MAF) currently has no protocol on disaster victim identification through dental characteristics. Since service members are almost in constant move over a period of time and the chances of loss are greater, recommendations are made as to improve the maintenance and storage of dental records. Keeping the dental cards (BAT F3) in the AFDC rather than at the various AFMC or Army Hospital and having the dental records in a folder separate from the medical document is suggested. The setting up of a computerised central repository where all the records are kept for in-service and out-of-service personnel and their families is suggested. Recommendations are also made in this thesis for the improvement of the storage of dental x-rays, separate dental records (separate design of dental cards) for the servicemen's dependents, and the marking of removable dental prostheses. It is suggested that all MAF dental personnel should be trained in forensic dental identification procedures rather than relying upon a few trained personnel in the dental identification section in anticipation of disasters that could occur at a location distant from military installations.
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It is also suggested that continuing education of dental personnel, especially dental officers, in the MAF be implemented with regard to forensic knowledge since the subject is relatively new in Malaysia. The subject of forensic dentistry should be introduced to the final year dental undergraduates at the University of Malaya.

The forensic dentists are dentistry's detectives helping to identify unknown persons and to provide evidence to assist criminal justice. There is little glamour in a job that requires hard work, dedication and attention to detail. Forensic dentistry is integral to identification of the dead from major disasters, criminal investigations involving bite marks, child abuse and sexual abuse in known and unknown living victims.
ACKNOWLEDGMENT

I would like to thank the Ministry of Defence for sponsoring me to attend this course, and the Director of Medical Services (DMS) of the Malaysian Armed Forces for his confidence in me.

I am grateful to Col (Dr) Mohammed Termidzi Junaidi [Deputy DMS (Dental)] for his encouragement and it was his suggestion that forensic dentistry be the basis for my thesis.

I am grateful to Associate Professor Peter D Barnard for his tireless advice, guidance and unlimited working hours of going through my thesis.

I would like to extend my thanks to Dr Chris Griffiths (Forensic Unit, Westmead Hospital) for giving me some slides and invaluable hands-on experience on forensic identification through dental means during the period of my stay in Sydney. The hands-on experience gave me some insight to the practicality of identifying remains via dental means.

Lastly, I acknowledge the support and encouragement from my wife, Fauziah, to me for the period of this course.
vi

DEDICATION

Praise be to Allah, Lord of the worlds. The Beneficent, the Merciful.
Owner of the Day of Judgment. Thee (alone) we worship; Thee (alone) we ask for help.
Show us the straight path. The path of those whom Thou hast favoured.
Not (the path) of those who earn Thine anger nor of those who go astray.
(Al Fatiha, 1:1-7)

This thesis is dedicated to my children, HUDA and MOHAMMAD FARUQ.

The thought of the Almighty and them, gave me the strength and endurance.

O ye who believe! Endure, outdo all others in endurance, be ready and observe your duty
to Allah, in order that ye may succeed. (Al-Imran 3:200)
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<td>AFDC</td>
<td>Armed Forces Dental Centre</td>
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<td>AFMATI</td>
<td>Armed Forces Medical Administration and Technical Instruction</td>
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<tr>
<td>AFMC</td>
<td>Armed Forces Medical Centre</td>
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<td>BW</td>
<td>Bitewing Radiograph</td>
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<td>CAPMI</td>
<td>Computer Aided Post-Mortem Identification</td>
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<td>CILHI</td>
<td>Central Identification Laboratory Hawaii</td>
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<td>FDI</td>
<td><em>Fédération Dentaire Internationale</em></td>
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<td>HQ</td>
<td>Headquarters</td>
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<td>INTERPOL</td>
<td>International Criminal Police Organisation</td>
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<td>MAF</td>
<td>Malaysian Armed Forces</td>
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<tr>
<td>MDC</td>
<td>Medical and Dental Corps</td>
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<tr>
<td>MMDC</td>
<td>Malaysian Medical and Dental Corps</td>
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<td>MINDEF</td>
<td>Ministry of Defence</td>
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<td>OPG</td>
<td>Orthopantomograph</td>
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1 INTRODUCTION

Dental evidence was used for 'identification' purposes as far back as 2500 BC and possibly earlier (Woolridge 1980). This form of evidence was further utilised in cases concerned with homicide (Harvey 1968) and war-related victims (Luntz and Luntz 1973). With the more recent increase in the world population and travel (especially air transportation) dental evidence has played an indispensable role in identification of mass disaster victims (Luntz and Luntz 1973, Haines 1973).

The science of forensic dentistry is based on the fact that teeth, dental restorations, dental prostheses, anatomical characteristics of soft and hard tissues and the overall oral morphology present a vast number of relatively stable individual characteristics which is something of a paradox where teeth can be destroyed relatively rapid in vivo and yet are almost indestructible post-mortem (Newbrun 1978).

As the science of forensic dentistry advanced over the years, dental evidence has established itself to be invaluable in personal identification and criminalistics. In the eyes of law, it is a valid and reliable method that ranks favourably with other scientific methods of comparison such as fingerprints.

Forensic dentistry, as defined by Keiser-Nielsen (1967) in the editorial of Scand Soc Forensic Odontology Newsletter cited by Harvey (1976), "...is that branch of dentistry, in the interest of justice, deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings."

Forensic dentistry in Malaysia is almost an unknown entity. The University of Malaya is the only university in Malaysia that conducts a course in dentistry. The fact that forensic dentistry is not part of the curriculum and the lack of a forensic dental 'expert' in the country at the moment attributes to the current situation. As there is little formal training in this field throughout the world, the tendency is to rely on a relatively few specialists that may be drawn from hospital consultants, academics or general practitioners.
1.1 **SCOPE OF FORENSIC DENTISTRY AND ITS APPLICATION**

The scope of forensic dentistry is broad and challenging. It varies with the cases and problems they presented as no two cases present the same characteristics (Keiser-Nielsen 1975). The collection of dental evidence, its interpretation and presentation in a form most useful to those requesting it, and its adequacy may only be realised by individuals who have made a special study of the particular techniques involved.

Theoretically, any dental advice required would fall within a broad definition of forensic dentistry but by custom, any legal reports on injuries to living patients, opinions on the prognosis of such injuries and seeking of further treatment would usually be sought either from the practitioner directly concerned with the care of the patient or from a consultant to whom the patient or the dental record may be referred. Therefore, the best preparation for such an activity is a sound understanding of the principles of general dentistry and a particular interest in the development, growth and age changes in the teeth, their supporting structures, facial bones and the soft tissues.

Cameron and Sims (1974) divided forensic dentistry into 3 major fields of activity, namely:

a. **Civil** This includes:
   * Malpractice and all aspects which may lead to criminal charges (fraud)
   * Neglect where damages may be sought and may result in criminal investigation
   * Identification of individual remains where death is not due to suspicious circumstances whether in fragments or complete. This include age assessment
   * Identification of living person (amnesia cases or senility)
   * Natural or mass disaster involving travel by land, sea and air or fires

b. **Criminal** This includes:
   * Identification of person - living or dead
   * Bite mark analysis either in foodstuff, on the assailant or on the victims (self-inflicted or by others)

c. **Research**
   * Research based on examination of evidence of cases (criminal or civil)
   * Academic training and courses and post-graduate tuition
Goldman (1982) appreciated the dentists' role in the following situation:

a. Routine identification. Identification of unknown human remains in the various stages of decomposition
b. Mass disasters. The tasks of identifying must be systematically carried out
c. Bite mark analysis
d. Child abuse cases
e. Expert testimony in civil and criminal litigation

The fundamental element of forensic science of unknown remains is records comparison as most methods employed in cases of identification of remains are dependent upon ante-mortem records being available for comparison with the post-mortem. Even in the presence of overwhelming dental evidence, if there is insufficient or inaccurate ante-mortem dental information, identification of remains will be difficult. The completeness, recency and accuracy of these records will determine the outcome of the forensic evaluation.

More often than not, dentures (full or partial) may be found within or close to the scene where the body was found. They can be useful aids to identification. The chances of identification of an edentulous person wearing dentures is less likely when compared with a dentate person. It would be useful if the dentures are marked or labelled. However, proving a denture belongs to the deceased can be quite laborious and time consuming. It will be necessary to demonstrate that the denture had been worn by the deceased and not by others. This may be achieved by fitting the denture into the mouth and checking for fit in relation to soft tissues, bony protuberances, position of teeth in relation to natural faceting on the artificial teeth and any modifications made to accommodate particular anatomical features in the oral cavity.

In summary, the field of modern forensic dentistry encompasses a wide range of subjects that include identification of unknown deceased (or living), the utilisation and interpretation of bite mark evidence, the examination and evaluation of child abuse and personal injury cases, and forensic dental research and education. It is apparent that forensic dental work has differing objectives to those of conventional dental education and requires investigation and considerations different from routine dental practice.
1.2 HISTORY OF FORENSIC DENTISTRY

"Histories make men wiser". The study of the history of forensic dentistry is more of collecting widely separated anecdotes involving application of dentistry to a quest of law. A review of literature indicates that one of the first dental identification cases recorded was in 2500 BC when two molars linked together by gold wire were found in a tomb in Giza (Harvey 1966). The utilisation of tooth impressions in seals for deliberate legal personal identification dates back approximately 900 years (Woolridge 1980).

The first evidence of dental findings being used in a forensic manner is associated with Emperor Nero dated from 45 - 70 AD. There is uncertainty as to the actual events but it probably occurred in one of the following ways:

a. Nero’s mother, Agrippina had her husband’s (Emperor Claudius) mistress, Lollia killed and her head brought for identification by a discoloured tooth;
b. Nero’s mistress, Sabina had Nero kill his mother who was identified by 2 maxillary canine teeth;
c. Sabina had Nero kill his first wife and identified her by a discoloured tooth.
(Baker 1982)

In America, one of the earlier cases in identification via dental evidence concerned the death of a physician and war leader, General Joseph Warren, in 1775. Dr Warren was killed during the Battle of Bunker Hill in Boston and buried in a mass grave. Dr Paul Revere, a silversmith by profession (and dentist), who had made a denture containing a silver and ivory bridge, identified Dr Warren’s body via this bridge (Luntz and Luntz 1973).

Dr George Parkman, a professor in Harvard University, was killed by Dr JW Webster in November 1849. The body was partially burned and dismembered. A charred fragment of a tooth fused to gold was found in the furnace of the house. The trial relied heavily on Dr NC Keep who had made a removal partial denture for Dr Parkman. The hanging of Dr Webster in 1850 ended the first major trial based largely on dental evidence (Luntz and Luntz 1973).
In 1837, at the height of the child labour problem in England, Dr E Saunders after examined 1,046 children and established that the eruption pattern of teeth was a better criterion for age in children than was their height. Examination of teeth then became the official method for determining age for employment in the textile industry in England (Baker 1982).

The first major disaster case in which dental expertise was used for identification of victims was the Bazaar-de-la-Charite fire in Paris in 1897. Dr Amoedo, a practising dentist in Paris, along with two French dentists identified most of the 126 victims who had attended the ball (Amoedo 1897). In 1898, Dr Amoedo wrote L'Art Dentaire-en-Medecine Legale, the first text on forensic dentistry (Figure 1). He was later identified as the father of forensic dentistry for his work.

In 1906, two men were arrested as suspects in a burglary in northern England. During the burglary, one of the culprit took a bite from some cheese. Impression of the dentitions of the suspects were made and the casts from one fitted the bite marks in the cheese. This seems to be the first bite mark identification case used to convict a wrongdoer.

Figure 1 Cover of the first book on forensic dentistry
Source: Luntz & Luntz (1973)
In 1933, the unidentifiable body of Linda Agostini (the Pyjama Girl) was discovered in a culvert near Albury, NSW Australia. It was initially believed there was a discrepancy between initial dental evidence and the ante-mortem records. The case was reopened following exhumation 11 years later. A positive identification was later obtained when it was shown that the dental evidence was actually consistent with the original ante-mortem record (Cleland 1944).

The use of computers can be traced back to the 1940s when in 1946, Welty and Glasgow utilised a computer and illustrated that up to 500 cards with dental information could be sorted out in one minute. In 1947, Dr Tattersall suggested that the Hollerith system of punch cards would be most beneficial in compiling dental data (Woolridge 1980).

In the early 1950s, LeMoyne Snyder, a forensic expert from California, introduced a concept that utilised the wrinkles and cracks of the lips as a method of identification. The concept of lip prints (chelioscopy) was thoroughly studied by Japanese investigators as evidence and proved helpful in 3 Japanese cases in the solution of identification problem. Professor Suzuki of Tokyo and Tsushihashi made detailed studies in this field and developed great expertise in this area (Tsushihashi 1974).

In April 1968, a badly mutilated body which was found on the railway line at Mt. Kuringai near Sydney and was positively identified as a patient of Parramatta Mental Hospital who had been missing for several weeks. The identification was made possible by an upper acrylic denture bearing a name inscribed on it (Shroff 1973).

In Royal Malaysian Air Force (RMAF) history, there were 79 fatal air crashes (RMAF aircraft) from 24th October 1961 to June 1991, which involved 102 military and paramilitary personnel and 20 civilians. The worst accidents were in November 1989 (18 paramilitary; 3 military personnel killed) and December 1989 (16 military personnel) (MINDEF 1991).

The most publicised role of dental identification is that associated with air disaster. Table 1 was compiled by Dorion in 1990 and lists the findings of ten major disasters. Table 2 lists the findings of 13 investigators of fatal crashes relating to the use of dental identification between 1951 and 1972.
Table 1  Findings of ten major disasters involving eight airlines, one steamship and one a mass-suicide.  
Source: Dorion (1990)

<table>
<thead>
<tr>
<th>Location / State</th>
<th>Date</th>
<th>Airline</th>
<th>Death</th>
<th>Dental</th>
<th>Dental + Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 SS Noronic</td>
<td>17.9.49</td>
<td>@</td>
<td>118</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>2 Woodridge,Ontario</td>
<td>05.7.70</td>
<td>Air Canada</td>
<td>109</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>3 Miami,USA</td>
<td>29.12.72</td>
<td>Eastern</td>
<td>101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Pago Pago</td>
<td>31.01.74</td>
<td>Pan Am</td>
<td>96</td>
<td>51%</td>
<td>57% &amp;</td>
</tr>
<tr>
<td>5 Canary Island</td>
<td>27.03.77</td>
<td>PanAmKLM</td>
<td>326</td>
<td>156%</td>
<td>48%</td>
</tr>
<tr>
<td>6 San Diego,USA</td>
<td>15.09.78</td>
<td>PSA</td>
<td>144</td>
<td>110%</td>
<td>76% 31% 9%</td>
</tr>
<tr>
<td>7 New Orleans</td>
<td>09.07.82</td>
<td>Pan Am</td>
<td>154</td>
<td>93%</td>
<td>80%</td>
</tr>
<tr>
<td>8 Dallas,USA</td>
<td>02.08.85</td>
<td>Delta</td>
<td>130</td>
<td>88%</td>
<td>68% 23% 15%</td>
</tr>
<tr>
<td>9 Gander, Newf’dland</td>
<td>12.12.85</td>
<td>Arrow Air</td>
<td>256</td>
<td>174%</td>
<td>68% 6% 5%</td>
</tr>
<tr>
<td>10 Jonestown, Guyana</td>
<td>Nov 78</td>
<td>mass murder</td>
<td>913</td>
<td>226%</td>
<td>25%</td>
</tr>
</tbody>
</table>

| TOTAL | 2347 | 765 ?% |

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Time</th>
<th>Computer</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>no</td>
<td>120</td>
</tr>
<tr>
<td>12</td>
<td>16</td>
<td>yes</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>no</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>no</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>6</td>
<td>no</td>
<td>68</td>
</tr>
<tr>
<td>30</td>
<td>4</td>
<td>yes</td>
<td>220</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>39 &amp;</td>
<td>6</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>7</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>

Legend for table 1.

@ S.S Noronic Steamship.
# Dental personnel.
& 6 dentists, 1 hygienist, 6 dental assistants. 6 days of intensive work and 4 additional weeks of continued investigation. Only 90 of the victims were returned for autopsy.
&& 6 intensive weeks of work for 39 dental personnel; 4 between Dec 24 and mid-Jan; 2 from mid-Jan to Feb 21.
* Total time spent on dental identification.
$ 583 people died and 69 survived. 326 Americans on Pan Am were flown to Dover Air Force base for identification. 20 full time dentists for 2 weeks 7 days/week for 12 hours/day plus 5 dentists for additional 2 weeks and 4 for 2 weeks.
= 135 died in jet, 2 in Cassna, 7 on ground; 6 persons did the majority of dental identification; up to 30 were involved in one form or another.
** Hours actually spent on the dental identification.
### Table 2
Findings of 13 Investigators of fatal crashes between 1951 and 1972.
Source: Dorlon (1990)

<table>
<thead>
<tr>
<th>Authors</th>
<th>No of victims</th>
<th>Dental</th>
<th>Id %</th>
<th>Dental + Other %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teare 1951</td>
<td>28</td>
<td>3</td>
<td>11</td>
<td>-</td>
</tr>
<tr>
<td>Honolulu 1962</td>
<td>27</td>
<td>14</td>
<td>52</td>
<td>-</td>
</tr>
<tr>
<td>Haines 1967</td>
<td>72</td>
<td>34</td>
<td>47</td>
<td>6 8%</td>
</tr>
<tr>
<td>Keiser-Nielsen 1963</td>
<td>42</td>
<td>10</td>
<td>24</td>
<td>18 43%</td>
</tr>
<tr>
<td>Keiser-Nielsen 1963</td>
<td>101</td>
<td>0</td>
<td>0</td>
<td>45 45%</td>
</tr>
<tr>
<td>Salley 1963</td>
<td>127</td>
<td>62</td>
<td>49</td>
<td>-</td>
</tr>
<tr>
<td>Fisher 1963</td>
<td>81</td>
<td>3</td>
<td>4</td>
<td>13 16%</td>
</tr>
<tr>
<td>Blair 1964</td>
<td>23</td>
<td>3</td>
<td>13</td>
<td>10 43%</td>
</tr>
<tr>
<td>Stevens &amp; Tarlton 1966</td>
<td>218</td>
<td>21</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Harmeling et al 1966</td>
<td>57</td>
<td>43</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>Haines 1972</td>
<td>78</td>
<td>58</td>
<td>74</td>
<td>-</td>
</tr>
<tr>
<td>Boone County, Ky 1967</td>
<td>67</td>
<td>19</td>
<td>28</td>
<td>-</td>
</tr>
<tr>
<td>Van Wyk 1969</td>
<td>123</td>
<td>6</td>
<td>5</td>
<td>25 20%</td>
</tr>
<tr>
<td>Peterson &amp; Kogan 1971</td>
<td>109</td>
<td>53</td>
<td>49</td>
<td>12 11%</td>
</tr>
<tr>
<td>Ashley 1972</td>
<td>162</td>
<td>70</td>
<td>43</td>
<td>-</td>
</tr>
<tr>
<td>Ashley 1972</td>
<td>64</td>
<td>10</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>Waaler 1972</td>
<td>24</td>
<td>6</td>
<td>25</td>
<td>9 38%</td>
</tr>
<tr>
<td>Luntz &amp; Luntz 1972</td>
<td>28</td>
<td>25</td>
<td>89</td>
<td>-</td>
</tr>
<tr>
<td>Beckmann 1974</td>
<td>148</td>
<td>59</td>
<td>40</td>
<td>63 43%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1579</strong></td>
<td><strong>499</strong></td>
<td><strong>32</strong></td>
<td><strong>189 12%</strong></td>
</tr>
</tbody>
</table>

In summary, forensic dentistry will always be an important forensic resource as it offers an important alternative in which evidence may be studied in the administration of justice. As society becomes more advanced and sophisticated, more safeguards for justice are required together with more exacting evidence. The presence or absence of a discoloured tooth may have been satisfactory in Nero's time but would it be satisfactory now to an insurance company? Forensic dentistry is expected to make significance advances in scope and depth in a modern world where the society is highly mobile.
1.3 NEED FOR IDENTIFICATION

'Persons are born with an identity and therefore deserve the right to die with an identity'

Identification of an unknown body or a living person is a statement based on a certain proven facts which correspond to those of that specific person, that is, they originate from one and the same individual. The need for identification arises when people die in unexpected circumstances. There is no meaning in trying to help the dead but when the interests of close family of the dead is taken into consideration, then the importance of identification of the dead is realised. The importance of forensic establishment of the identity of unknown human remains rests upon legal, humanitarian, criminal and research/assessment circumstances.

Legal probating of wills, payment of insurance and pensions, business interaction, lawsuits and remarriage of the spouse are all dependent upon a valid death certificate. The death certificate in the name of the deceased represents the legal proof of an individual's death. A living person (e.g. as in coma cases, loss of memory from attack, shock, old age, senility or abandoned ‘hit-and-run’ accident victims, and psychiatric cases) need to be positively identified. On occasions, people deliberately wish to give a false impression that they have passed beyond the confines and legal restrictions, to escape from bad debts or an unhappy marriage or from a desire to reap, prematurely, the benefits of life insurance and these are further examples for forensic considerations (Harvey 1976).

Humanitarian considerations include termination of emotional strain resulting from the unknown whereabouts of a family member (e.g. in missing person or in the case of service personnel who are declared as missing in action (MIA) during armed conflict) and religious interests of the next of kin (e.g. proper funeral service). Conversely, the conclusion that the remains are not those of a particular individual in question do represent a significant psychological contribution by the identification expert. Members of the military community have, whenever possible, a duty to prevent this additional burden on a family already suffering a great loss.
In *criminal* cases such as homicide, suicide or death by violence, evidence may depend upon identification of the victim and establishment of the victim's relationship to a suspect. The victim's identification is fundamental to the entire police investigation team as the victims identity may become a major clue in that investigation (Rothwell, Haglund and Morton 1989). Recognition by law enforcement officials that a serial killer is active is of prime importance to the initiation of the investigation; positive identification of the victim becomes a major clue to help determine patterns of the killer in the cases of Jack the Ripper, David Berkowitz (the 'Son of Sam'), Kenneth Bianchi (the 'Hillside Strangler') and Peter Sutcliffe (the 'Yorkshire Ripper') where the perpetrators went into great lengths to dispose of the body in such a way that identification is not readily apparent. On the contrary, an unidentified murder victim usually results in an unsolved case as in the Green River Murders which continue to be unsolved and remain the largest series of unsolved homicides in the United States.

During *research/assessment* of an aircraft accident, identifying the air crews is important in determining the cause and manner of the accident. The accident may be due to human error or machine malfunctions. Victim identification provides important data which may lead to improvement of the man-machine relationship as it applies to aircraft to prevent future accidents. Identification of air accident victims enables an assessment to be made regarding known seating locations and crash scene data to allow reconstruction of crash mechanics and the mechanism of injury patterns. These findings will certainly answer as to why the survivors lived and why and by what means the victims died (Sopher 1976).

*In a military situation*, it is critical to verify the death of a soldier who had access to sensitive information to ensure that the information is not compromised. For military manpower assessments, it is necessary to accurately identify the dead in order to adequately replace soldiers lost to units.
1.4 AIM OF THE THESIS

The problem of identifying human remains has been and continues to be a problem facing the military. Armed conflict produces mass casualties, many of whom are badly mutilated or burned beyond recognition. Even a bomb explosion and the subsequent collapse of building can result in mutilation, charring and fragmentations of human remains (Gillespie 1985).

The dental service of the Medical and Dental Corps (MDC) of the Malaysian Armed Forces (MAF) serves the three branches of the military service i.e the Army, Royal Malaysian Air Force and the Royal Malaysian Navy. Since military personnel are itinerant, it is important that their dental records should be readily available. Service life itself poses administrative dilemmas. Frequent moves or just regular postings, service in remote areas and the disturbances of war are some examples. The possibility of loss of dental records is greater than for civilians even though the risk is less in peacetime.

The MAF relies heavily on air transportation as the main mode of transport from Peninsular Malaysia to the states of Sabah and Sarawak on the island of Borneo. When travelling from one town to another in Sabah and Sarawak, the preferred transport mode is by air as travel by land is rough and lengthy. Currently, there are no guidelines or standard operating procedures with regard to forensic dental identification in the MAF.

The aims of this thesis are:

a. to review the available english language literature on forensic dentistry, especially for areas involving usage of dental characteristics in identifying unknown persons and human remains; and

b. to make recommendations that may improve the forensic dentistry capability of the dental services of the Malaysian Armed Forces.

Recommendations are to be focused on the areas of current deficiencies in dental examination and charting, maintenance and storage of dental records (including radiographs and computer use), prosthesis marking, continuing education of dental personnel, and organisation of dental forensic services.
2 METHODS OF IDENTIFICATION

Various methods can be employed for establishing the identity of unknown human remains. Some methods have been shown to be scientifically reliable (e.g. fingerprints) while others are less reliable. However, the corroboration of data obtained by several less reliable methods may enhance the probability of correct identification beyond that which could be obtained by any one reliable method alone (Sopher 1976).

All the identification methods employed are dependent upon comparison between the post-mortem and the ante-mortem records as well as the completeness and the degree of decomposition of the remains. The methods for identification include:

a. Visual recognition  
b. Personal effects  
c. Fingerprints  
d. Medical/autopsy findings  
e. Radiographs  
f. Skeletal remains  
g. Serology  
h. Hair examination  
i. Association/exclusion  
j. Photograph  
k. DNA - based identification  
l. Dental characteristics

2.1 VISUAL RECOGNITION

Visual recognition represents the most frequent method of identification. It can only be utilised where the body, especially the facial features, is well preserved and relatives or friends can be located soon after death. The value of this method is limited since in the summer heat, the body may not be recognisable after as short as 24 hours post-mortem. Additionally, examination of unidentified remains by relatives is often a highly emotional experience and failure to achieve identification is not uncommon and, thus, it is possible for an erroneous identification to be made (Sopher 1976). Therefore, visual recognition is considered to be least reliable.
2.2 PERSONAL EFFECTS
Examination of personal effects like clothing, jewellery, wallets, credit cards, personal documents and laundry markings are frequently very helpful in identification, provided that there has been no attempt at criminal interchange of identity. In the case of military personnel, military identification tags ('dog tags') found around the neck or identification bracelet on the wrist and the presence of fire-resistant flight clothing of the air force pilots and the air crews can be helpful (Buchner 1985).

However, identification via personal effects is not generally considered reliable (since loose objects can be mislaid or switched), but is a useful clue leading to subsequent identification by more scientific methods. In some instances, personal belongings may serve as the only means of identification.

2.3 FINGERPRINTS
The specificity of matching fingerprints cannot be challenged since no two sets of prints are alike. When the hands of the deceased are well preserved, fingerprints provide the basis for rapid conclusive identification. With improved methods of fingerprinting, it is possible today to obtain adequate prints even in cases of severe burning or early decomposition. It is also possible to obtain fingerprints from the internal aspect of epidermis (if the external part is damaged) and even from denuded fingers (if the epidermis is unavailable). The disadvantage of fingerprints is the lack of ante-mortem records for comparisons. However, this problem may be overcome in some cases by obtaining prints from the home of the suspected deceased.

2.4 MEDICAL/AUTOPTSY FINDINGS
External examination of remains can give information regarding sex, relative age, race, estimate of living stature and weight, and colour of the eyes and hair. It focuses on skin markings such as tattoos, moles, and scars due to prior surgery or injury.
Internal examination provides additional information concerning the cause of death, as well as evidence of prior disease, to compare with medical records. Evidence of surgical removal of organs (e.g. absence of appendix) can serve as a basis for comparison. In severely burned bodies, sexes can be distinguished by examination of the internal genital organs.

2.5 RADIOGRAPHS

The radiological identification method is based on precise matching of ante-mortem and post-mortem radiographs to discover some combination of normal anatomical landmarks sufficiently unique to provide convincing proof of identity. The identifying points of bone are permanent and not subject to easy destruction. Radiological examination is also helpful in screening of foreign material and metallic objects not observed during medical examination.

The radiological evaluation of teeth is valuable for positive comparison. Distinctive shapes of restorations, bases under restorations, tooth and root shapes, and endodontic treatment can only be identified by examination of radiographs (De Vore 1977).

2.6 SKELETAL REMAINS

Skeletal remains contain an abundance of information which can lead to the reliable determination of age, sex, race and stature of the individual in life. However, the skeleton lacks specificity and personal identification is usually accomplished by means of the dentition (Sopher 1976). The value of skeletal examination is that by determining personal characteristics of the deceased (such as age, sex, race and stature), it greatly narrows the field of possible identities. Dissection of long bones to determine height and examination of the pelvic bones to reveal sex are some examples.
2.7 SEROLOGY

The study of blood and other body fluids, such as saliva, has an important forensic role. The relative frequencies of the various ABO, Rh and other blood groupings make serological identification by itself not specific; however, in group casualties, it may serve to reinforce other methods in establishing a definite identification. Methods of greater sensitivity have been developed to determine human blood groups. One can identify blood group antigens in fragments of congested tissues such as liver or skeletal muscle. Antigen may still be detectable in the bone marrow even if the tissue is in a state of advanced decomposition.

2.8 HAIR EXAMINATION

Examination of hair is sometimes useful in the identification procedure. Microscopic examination may indicate race or differentiate human from non-human remains. Neutron activation analysis is now available for comparative identification of hair and nail clippings, provided ante-mortem samples of these are available for comparison.

2.9 IDENTIFICATION BY ASSOCIATION/EXCLUSION

This method is possible only in a 'closed disaster' situation where an accurate list is available and the corresponding number of bodies have been found. The identity of a woman in a plane crash can be made if it is known that all passengers aboard were male except for one female, and the post-mortem yielded female sex organs in only one of the remains (Sopher 1976). Whilst this particular method is not considered reliable, it is sometimes the only method possible under certain conditions, i.e correlation of established ante-mortem facts with non-specific post-mortem data.
2.10 PHOTOGRAPHS

Photographs of the remains are indicated when special physical features are present such as a unique shape of the external ear, a diastema in the dental arch or a "toothy" smile that shows prominent anterior teeth (Figure 2). Comparison with photographs obtained during life is possible. Close-up colour or black and white photographs provide an objective record of the case. In some instances, special photographic applications such as ultra-violet and infra-red photography, photograph - video superimposition techniques, electronically enhanced photo images, laser photograph, or holograph may be used (Beckstead et al 1979).

Figure 2 'Toothy' smile photograph. Skull and photograph of a murder victim. Source: Shroff (1973)
2.11 DNA - BASED IDENTIFICATION

Molecular genetics has had a profound impact on the field of medical genetics. Man has substantial differences in DNA sequence on an individual basis, making it possible to associate the naturally occurring variations from one man to the other, as in fingerprints. The forensic scientists and legal profession have accepted genetic marker identification as a valid science for prosecution, defence, and jury consideration in case decisions. The informative character of these methods has been useful but lacks a high degree of discrimination and identification due to low alleles frequency and limited markers. Markers used include blood antigens, HLA, isozymes, saliva, semen and serum proteins (Caskey and Hammond 1989). These approaches have been helpful for exclusion but frequently lack a high degree of positive identification and require multiple testing. Even though molecular genetics is having a major impact on the judicial system (DNA - based testing provides an identification method that far exceeds present forensic methods), it needs a quality assurance programme that not only validates the laboratory procedures used in the forensic laboratory, but the genetic principles on which the reports are based.

2.12 DENTAL CHARACTERISTICS

Teeth are the most durable of the human tissues and the materials used in dental restorations are also extremely resistant to destruction by biological, chemical and physical elements such as intense heat (Gustafson 1966). Thus, dental identification becomes the single most accurate means in identification of remains when both visual and fingerprint methods are ineffectual, for instance in cases where there has been advanced decomposition, conflagration, extreme fragmentation and skeletonisation of remains.

The adult dentition is composed of 32 teeth; each possessing 5 surfaces visible on oral examination. The innumerable combinations of missing teeth, carious lesions, restorations and prostheses involving these 160 surfaces form the basis for the specificity of dental identification. The use of radiographs of the teeth and jaws provides data on the anatomic variations of the teeth (mainly the roots), morphology of the restorations, root canal fillings,
trabeculae bony patterns, etc. It should be emphasised that sometimes the recovery of a single tooth or a jaw fragment may be enough to make a positive identification, provided an ante-mortem record is available.

Furness (1971) estimated, by the use of computer, that there are over two billion possibilities in charting of an adult dentition. This would rule out any possibilities of two adults having exactly the same or identical mouths. Sognnaes et al (1982) and Brown et al (1987) demonstrated that identical or monozygous twins are not dentally identical despite similar developmental morphology of individual tooth; however, the arrangement of their teeth may sometimes reflect a mirror image of the twin-pair bite mark patterns.

The disadvantage of the dental identification system (as with fingerprints) is that ante-mortem records are not always available or easily obtained if no central repository exists. Furthermore, a list of possible identities must be established before corresponding records can be obtained.

In summary, the fingerprinting, DNA-based and dental identification methods are the most scientifically reliable and most specific. Nevertheless, other methods which bear a lesser degree of specificity are valuable assets in identification. The data derived from all these methods may be pooled as the greater the number of criteria for comparison, the more reliable is the comparison.
3 COLLECTION OF DENTAL DATA

The aim of the dental investigation is to record the dental status of the body and significant features of the jaws and soft tissues. Some authors feel that the post-mortem dental examination should begin at the site where the body is found since the fire and police officials cannot always recognise dental remains that may exist under conditions surrounding the decomposed, charred or traumatised and mutilated bodies (Harvey 1976, Sopher 1976).

3.1 TYPES OF DENTAL EXAMINATION OF HUMAN REMAINS

The degree of decomposition of the body or the head would normally dictate the type of examination. For the purpose of classification, the degree of decomposition can generally be described as: recent death; partially decomposed; skeletonised; mutilated; or burned.

A visual identification is normally possible in recent death or with head in normal position. Examination of the mouth may be difficult due to rigor mortis. Preferably after autopsy is completed, the maxilla and mandible are removed to make oral examination easier. After charting has been completed, radiographs should be taken and, if possible, developed at the site for assurance that all the desired radiographic information has been obtained (Luntz and Luntz 1973). Photographs of any natural teeth present should be made with the teeth in occlusion along with pictures of the occlusal and buccal surfaces. Rigor mortis usually disappears 20-30 hours post-mortem after which oral examination without resection of the jaws can be carried out.

The partially decomposed head/body is most offensive to work with because of the disagreeable odour and repulsive sight especially when maggots are present. The head should be treated with care if there is a possibility of visual identification. Jaw resection is advisable (Ashkinazi 1989).

The completely decomposed head - skeletonised is the easiest to work on as access is not a problem (Figure 3 as taken from Luntz & Luntz 1973). Care should be exercised in handling the teeth as they are likely to be brittle and may be easily lost from their sockets. A determination as to ante-mortem or post-mortem loss should be made.
A mutilated head is frequently complicated by fragmentation and facial distortion following an air crash, high-speed automobile collision or physical assault. The teeth may have been dislodged and scattered post-mortem over a wide area, resulting in loss of valuable evidence. All recovered pieces should be placed on the examining table as close as possible to their correct anatomical relationship with each other. Reconstructing the maxilla and mandible in this way makes it easier to chart, X-ray and photograph.

With a burned head the eyes, nose and lips may have been destroyed especially if resulting from burned out vehicles or tanks on the battlefield. The oral cavity may not be visible, the tissues are hard and unyielding and the mouth may be sealed. Resection of the jaw is indicated. It is advisable that all soft tissues are removed, together with the jaws, and immersed in a preservative solution.
3.2 TECHNIQUE OF POST-MORTEM DENTAL EXAMINATION

The aid which the dental expert can render depends upon the amount of exact dental data he can find and record. He should be allowed to examine the unknown body at the site of recovery and, in particular, to assist in the search for loose and displaced evidence. At the morgue or other place selected for examination, the dental examination will be performed last, often in conjunction with the medical autopsy.

Under ideal conditions, the dental examination of a human remains should be performed by a minimum of two persons familiar with dental terminology, one doing the examining and the other recording the data. Following the dental examination, the recorder and examiner should then reverse roles and re-examine the body to ensure accuracy. Alternatively, following the first examination and charting, the recorder reads out the charting with the examiner confirming the post-mortem dental charting. Photographs of the dentition are essential as a means of later review and also to substantiate the post-mortem dental record.

3.2.1 Exposure for dental examination

The exposure of the dentition for unhindered examination recording depends upon the state of the head. With the mutilated head, completely decomposed head and the heavily burned head, exposure is not as difficult as for the recent death and partially decomposed heads. Whether or not later viewing is a possibility, the dental expert must do his utmost to avoid unnecessary disfigurement of facial features during oral autopsy.

3.2.2 Post-mortem dental identification team

Based on the techniques of post-mortem dental examination, the post-mortem dental identification team should consist of dentists and dental auxiliaries; namely dental hygienists and chairside assistants who can also double-up as x-ray technicians, and dental technicians. As the hospital morgue is usually ill-equipped for proper dental examination or the site of accident is understandably without any proper equipment, it is advisable to be self-sufficient.
3.2.3 The dental identification kit

The instruments and equipment contained in a dental identification kit differ from those used routinely in the dental clinic. Since the forensic dentist is constantly on-call, it is advisable that the special armamentarium be retained intact, readily accessible and in good operating condition. As each case is different, it is quite impossible to predict precisely what is the complete armamentarium for a kit that is readily transportable. Items required for a dental identification kit have been suggested by Stimson (1977) as follows:

- Dental mouth mirrors
- Dental explorers
- Molt mouth props
- Scalpel - handle and blades
- Haemostats
- Surgical scissors
- Stryker autopsy saw/bone saw
- Flashlight and * batteries
- Gauze pads
- Dye disclosing solution
- Cotton swabs
- Cotton rolls
- Face masks
- Rubber gloves
- Plastic apron
- Toothbrushes
- Plastic bags
- Extension cords
- Dental charts
- Pens and pencils
- Clipboards
- Ruler - adhesive, mm
- Photographic equipment
- Radiograph films
- Portable x-ray and * generator
- Impression trays
- Rubber base impression material
- Spatula
- Plastic bandage
- * Super-Glue

*Recommended by Dr Chris Griffiths (1991), Forensic Dental Unit, Westmead Hospital Dental Clinical School, NSW, Australia.

3.2.4 The post-mortem dental chart

The post-mortem dental chart should be simple and have adequate space to depict restoration morphology. Appendix I shows the Dental Identification Form ‘B’, FDI format of charting for the dental status of human remains which is similar to the form used by Interpol (Appendix II). It is important to indicate any jaw segments which were not recovered as well as missing teeth, lost either ante-mortem or post-mortem. There should be an area in the chart reserved for general conclusions of the dentist.
3.3 THE POST-MORTEM DENTAL DATA

The post-mortem dental data may be recorded by using diagrammatic dental chartings, FDI international type forms, tape recordings, radiographs, photographs and/or models. A complete and comprehensive examination is always recommended. Failure to record a seemingly unimportant detail may later prove to be critical for a positive identification.

The most common parameters which have features of specificity and should be included are:

a. Number of teeth
b. Tooth loss
c. Restorations
d. Dental protheses
e. Dental caries
f. Malposed and rotated teeth
g. Anomalous tooth formation
h. Endodontic treatment
i. Bony pattern
j. Occlusion
k. Oral pathology
l. Unusual wear

3.3.1 Number of teeth

Assessment of teeth in the mouth should include those that are present and missing. It is also essential to be able to distinguish between deciduous and permanent teeth since deciduous teeth may occasionally be present in adults. Once the number of teeth are noted, determine which teeth are missing and the reason for their absence.

Absence of a tooth can be due to:

a. Clinically unerupted tooth
b. Developmentally missing tooth. Most commonly absent are third molars followed by lower second premolars, upper second premolars and upper second incisors
c. Impacted tooth e.g upper canines or lower third molars
d. Therapeutic extraction due to dental and periodontal disease or for orthodontic reason
e. Traumatic loss as a result of an accident, fall or blow
3.3.2 Tooth loss

It is important to determine the period when the teeth were lost from the arch. In post-mortem loss, either as a result of decomposition of the body or scavenging by animals, the bone surrounding the socket margins would be unresorbed and have a sharp profile whereas in ante-mortem loss, there is usually evidence of the healing process taking place within the socket; the varying degrees of bone remodelling from rounding of the rim in early repair to a complete fill-in of the socket with secondary bone formation (Figure 4). The period of teeth loss from the arch should be indicated by letters such as 'LPM' (lost post-mortem) or 'LAM' (lost ante-mortem) on the charting.

Figure 4 Ante-mortem vs post-mortem loss. Ante-mortem loss of tooth 36 shows remodelling of what was once a socket while the post-mortem loss of tooth 37 is characterised by a socket with a sharp edge.
Source: Sopher (1976)
3.3.3 Restorations

A tooth is generally restored due to loss of tooth substance from dental caries, fracture of tooth, any abnormal wearing away of teeth (for various reasons), or for an aesthetic reason. Restorations replacing areas damaged by dental caries are the most frequent and can involve single or multiple surfaces of any individual tooth. A full description of the restoration must be included in the post-mortem record and this must include the material used and the surfaces restored. Note any special corrective restoration (e.g. for median diastema).

3.3.3.1 Nomenclature of tooth surfaces and restored surfaces

The incisors and canines are considered as having 4 surfaces namely; mesial, distal, labial and palatal (upper) / lingual (lower) as in Figure 5 (Whittaker and MacDonald 1989).

The premolars and molars are considered as having 5 surfaces i.e. the occlusal, mesial, distal, buccal and palatal (upper) / lingual (lower) as in Figure 5. Restoration of posterior teeth may involve multi-surfaces either with silver amalgam or composite materials. The surfaces involved may be mesio-occluso-distal (MOD) surfaces or just an occlusal surface (Figure 6).

Figure 5  Nomenclature of anterior and posterior tooth surfaces.
Source: Whittaker and MacDonald (1989)
3.3.3.2 Types of filling materials used

The types of filling materials range from silver amalgam, tooth coloured materials (composite, glass ionomer cement), precious and non-precious metal used for inlays, crowns of gold or porcelain or porcelain fused to metal, and precious and non-precious metal bridgework with fused porcelain. Temporary dressings or fillings (e.g. zinc oxide eugenol) may also be used.

3.3.3.3 Recognition of restorative work

Tooth restorations may be dislodged and lost from the teeth in a body. It is, therefore important to be able to recognise areas of tooth substance loss caused by cavity preparation which can be determined by a definite outline when compared with other causes such as abrasion and attrition. Dental radiographs may substantiate the findings.
3.3.4 Dental prosthesis

A dental prosthesis is an appliance utilised in the replacement or substitution of missing tooth/teeth. Such an appliance is either removable (full or partial denture) or fixed (bridge). All removable appliances should be removed from the mouth and examined for any marking or labelling, which may lead to rapid identification. Other appliances may be present in the mouth, such as orthodontic appliances which may be fixed or removable.

3.3.4.1 Full denture

A full denture replaces all the teeth of a jaw and is constructed with an acrylic base with acrylic or porcelain teeth. It is necessary to be able to relate one denture to the opposing denture with which it has been worn. This should be readily accomplished when they have been worn as a set for a considerable period of time. However, after a prolonged period of wearing dentures or extraction of a tooth, there is reduction in size of the bone upon which the dentures rest which leads to a loose denture. Whilst it is difficult to say that a denture does fit an individual jaw, it is easy to say that the denture does not fit.

3.3.4.2 Partial denture

A partial denture replaces missing teeth in one jaw that has some natural teeth. Partial dentures are more variable than full dentures both in design and in the materials used in their construction. The simplest type would consist of an acrylic baseplate and acrylic tooth with or without clasps on the remaining teeth for retention. A partial denture with a cast metal base and acrylic teeth is an alternative which covers less soft tissue. Partial dentures are more specific as they fit into the gap(s) left by the missing tooth/teeth.

3.3.4.3 Fixed prosthesis - bridge

A bridge is a cemented device designed to span a gap in the dentition and is not easily removed by the patient or the dentist. The design usually consists of complete or partial crowns of the abutment teeth (the natural teeth at either side of the gap) connected to a pontic/pontics substituting for the missing tooth/teeth responsible for the gap (Figure 7).
Figure 7  Tooth replaced by a bridge and its radiograph.
Source: Whittaker and MacDonald (1989)

The radiograph in the lower picture confirms that crowns are placed on vital teeth on either side of the gap caused by the missing tooth (top picture). The metal core of the porcelain-faced pontic is also clearly evident.
3.3.4.4 Orthodontic appliance

Orthodontic treatment is carried out to correct abnormalities of position, angulation or rotation of teeth. It is normally carried out in adolescence but many young adults are now also receiving orthodontic treatment. Often teeth have to be extracted to allow space for the remaining teeth to be properly aligned. Some operators use removal appliances similar to partial dentures which have springs and other devices to apply pressure to individual teeth to achieve the desired movement. Alternatively, a fixed appliance can be used in which tooth movement is achieved by devices attached directly to the teeth. The preparatory stages of orthodontic treatment involve careful analysis including radiographs and study models of the teeth and these will normally be retained after treatment as part of the dentist records. Thus, orthodontic treatment is specific and can lead to rapid identification provided the treatment records are available.

3.3.5 Dental caries

Dental caries (decay) should be designated by both surface and configuration. Because dental caries seen on an ante-mortem chart or radiograph may have been subsequently restored, as evidenced in a post-mortem specimen, reference must be made to the record of treatment performed in the chart. This will clarify such findings which may not represent incompatibilities. Untreated dental caries may also lead to fractured teeth due to undermined enamel. It is important to take into account the date of any x-rays taken since the affected tooth/teeth may have been restored or extracted.

3.3.6 Malposition and rotation

Malposition refers to overcrowding, overlapping and abnormal spacing of individual teeth. Teeth may transposed so that their order is abnormal. This feature alone may result in a positive identification. Any mesial or distal rotation must be noted. Malposed and rotated teeth make excellent points of concordance during comparison of ante- and post-mortem data.
3.3.7 Anomalous tooth formation

Teeth of unusual shape, size or number are sufficiently rare to be useful in identification procedures which may or may not be noted in the ante-mortem record. These may include an extra cusp (cusp of Carabelli), supernumerary tooth, peg-shaped incisor or fused tooth.

3.3.8 Endodontic treatment

Endodontic treatment is specific since it is carried out less frequently than simple restorations such as amalgam fillings. Any tooth treated endodontically may be difficult to visually appreciated if the tooth has been restored with a crown or bridgework unless radiographs are taken. However, recognition of an endodontically treated tooth is useful (Figure 8). Clinically, the root canal appears larger than normal and would be round rather than oval in shape. A radiograph of the tooth will confirm the enlargement of the canal by instrumentation.

Figure 8 Recognition of restorative work - evidence of endodontic treatment
Source: Whittaker and MacDonald (1989)
3.3.9 Bony pattern
The medullary bone of the jaws may possess a characteristic trabecular pattern which can be duplicated on a post-mortem radiograph. Tooth angulation, root morphology, bone loss, specific changes in pulp chambers and pulpal outlines may also be assessed. Examination of the supporting alveolar bone may give some indication of periodontal diseases during life. The position of the maxillary sinus and its relation to the roots of upper posterior teeth should be taken into account during comparison of dental data.

3.3.10 Occlusion
Occlusion and malocclusion have been described according to whether the jaws have a normal relationship when closed and the teeth may be misplaced or whether the relationship of the maxilla to the mandible is disturbed. An example of classification to describe occlusion is Angle's classification. The amount of overbite and overjet should also be noted as well as the first lower molar relationship.

3.3.11 Oral pathology
Deviation from the normal anatomic configuration of the oral cavity applies not only to the dentition but also to the soft tissues, bony structures and tongue. Mandibular or maxillary tori, geographic or fissured tongue, dilantin-induced gingival hyperplasia, enamel hypoplasia and pre-existing bone pathology (cysts) are some examples. These abnormalities may impart varying degrees of specificity. The presence of healing or healed fractures and the establishment of an approximate time of injury could be of help in the identification process.

3.3.12 Occupation, habits and social position
The trained dentist can derived a great deal of information from the teeth and mouth with regard to occupation, habits and social position (Gustafson 1966). Occupational changes may be seen with such people as tailors, hairdressers, carpenters or shoemakers. Musicians especially those playing certain brass or wind instruments may produce permanent changes in the dentition which may relate to the particular occupation as shown in Figure 9. The same applies to pipe smokers who may develop broad areas of excessive wear as in Figure 10.
Figure 9  Occupational habits. This severe and characteristic pattern of wear was seen in a bagpipe player.
Source: Whittaker and MacDonald (1989)

Figure 10  Typical pipe smoker’s wear of teeth.
Source: Sopher (1976)
3.4 AGE DETERMINATION

A reasonably accurate estimate of age at death will considerably simplify the search for a possible identification of a body. Different ages may be assigned to the same individual according to what particular time scale is used. The chronologic age or real age is that measured by the calendar i.e in days, months and years. The skeletal age is determined by reference to tables of skeletal development. The dental age is determine by reference to the stages of development of the human deciduous and permanent dentitions and the changes which occur to them throughout life. Estimation of both the skeletal and dental ages are some attempts at realisation of the chronological or real age of the victim recognising that variation in development occurs between different individuals.

3.4.1 Skeletal age

The inherent value of skeletal age estimation is due to the processes of bone growth, maturation and aging changes which include appearance and union of ossification centres, symphyseal metamorphosis, cranial suture closure, histological remodelling of cortical bone and age-progressive pathological changes in the bone and joints of the individual.

3.4.2 Dental age

Up to 14 years of age, the teeth represent the most reliable indicator of age since during this period the developmental patterns and eruption schedules of the deciduous dentition are followed by the ensuing intermixing of developmental and eruption of the permanent dentition. Between 14 to 20 years of age, estimations are based on development of the root of the third molars which are more variable in development and eruption than the other permanent teeth and this renders it less reliable in assessment. Errors in estimation always exist as no two individuals grow and develop at the same rate. Heredity, environment, endocrine reaction and nutrition all play a part in the calcification and eruption of the teeth.

Massler and Schour (1941) charted the chronology of tooth development for simple direct comparison with radiograph (Figures 11 and 12). Table 3 presents a chronologic chart of the dentition based upon the Massler-Schour data. Caution must be exercised when using the third molar data as its eruption is erratic and on occasions it is missing.
Figure 11  Development chart of teeth from birth till six years.
Source: Sopher (1976)
Figure 12  Development chart of teeth from seven years to maturity.
Source: Sopher (1976)
<table>
<thead>
<tr>
<th>Teeth of Quadrant</th>
<th>Hard Tissue Formation Begins</th>
<th>Amount of Enamel Formed at Birth</th>
<th>Enamel Completed</th>
<th>Eruption</th>
<th>Root Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central incisor</td>
<td>4 mo. in utero</td>
<td>Five sixths</td>
<td>1½ mo.</td>
<td>7½ mo.</td>
<td>1½ yr.</td>
</tr>
<tr>
<td>Lateral incisor</td>
<td>4½ mo. in utero</td>
<td>Two thirds</td>
<td>2½ mo.</td>
<td>9 mo.</td>
<td>2 yr.</td>
</tr>
<tr>
<td>Cuspid</td>
<td>5 mo. in utero</td>
<td>One third</td>
<td>9 mo.</td>
<td>18 mo.</td>
<td>3½ yr.</td>
</tr>
<tr>
<td>First molar</td>
<td>5 mo. in utero</td>
<td>Gums united</td>
<td>6 mo.</td>
<td>14 mo.</td>
<td>2½ yr.</td>
</tr>
<tr>
<td>Second molar</td>
<td>6 mo. in utero</td>
<td>Gums tips still isolated</td>
<td>11 mo.</td>
<td>24 mo.</td>
<td>3 yr.</td>
</tr>
<tr>
<td>Deciduous dentition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central incisor</td>
<td>4½ mo. in utero</td>
<td>Three fifths</td>
<td>2½ mo.</td>
<td>6 mo.</td>
<td>1½ yr.</td>
</tr>
<tr>
<td>Lateral incisor</td>
<td>4½ mo. in utero</td>
<td>Three fifths</td>
<td>3 mo.</td>
<td>7 mo.</td>
<td>1½ yr.</td>
</tr>
<tr>
<td>Cuspid</td>
<td>5 mo. in utero</td>
<td>One third</td>
<td>9 mo.</td>
<td>16 mo.</td>
<td>3½ yr.</td>
</tr>
<tr>
<td>First molar</td>
<td>5½ mo. in utero</td>
<td>Gums united</td>
<td>5½ mo.</td>
<td>12 mo.</td>
<td>2½ yr.</td>
</tr>
<tr>
<td>Second molar</td>
<td>6½ mo. in utero</td>
<td>Gums tips still isolated</td>
<td>10 mo.</td>
<td>20 mo.</td>
<td>3 yr.</td>
</tr>
<tr>
<td>Mandibular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central incisor</td>
<td>3–4 mo.</td>
<td></td>
<td>4–5 yr.</td>
<td>7–8 yr.</td>
<td>10 yr.</td>
</tr>
<tr>
<td>Lateral incisor</td>
<td>10–12 mo.</td>
<td></td>
<td>4–5 yr.</td>
<td>8–9 yr.</td>
<td>11 yr.</td>
</tr>
<tr>
<td>Cuspid</td>
<td>4½ mo.</td>
<td></td>
<td>6–7 yr.</td>
<td>11–12 yr.</td>
<td>13–15 yr.</td>
</tr>
<tr>
<td>First bicuspid</td>
<td>1½–1½ yr.</td>
<td></td>
<td>5–6 yr.</td>
<td>10–11 yr.</td>
<td>12–13 yr.</td>
</tr>
<tr>
<td>Second bicuspid</td>
<td>2½–2½ yr.</td>
<td></td>
<td>6–7 yr.</td>
<td>10–12 yr.</td>
<td>12–14 yr.</td>
</tr>
<tr>
<td>Maxillary</td>
<td></td>
<td></td>
<td>2½–3 yr.</td>
<td>6–7 yr.</td>
<td>9–10 yr.</td>
</tr>
<tr>
<td>First molar</td>
<td>At birth</td>
<td>Sometimes a trace</td>
<td>2½–3 yr.</td>
<td>6–7 yr.</td>
<td>9–10 yr.</td>
</tr>
<tr>
<td>Second molar</td>
<td>2½–3 yr.</td>
<td></td>
<td>7–8 yr.</td>
<td>12–13 yr.</td>
<td>14–16 yr.</td>
</tr>
<tr>
<td>Third molar</td>
<td>7–9 yr.</td>
<td></td>
<td>12–16 yr.</td>
<td>17–21 yr.</td>
<td>18–25 yr.</td>
</tr>
<tr>
<td>Permanent dentition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central incisor</td>
<td>3–4 mo.</td>
<td></td>
<td>4–5 yr.</td>
<td>6–7 yr.</td>
<td>9 yr.</td>
</tr>
<tr>
<td>Lateral incisor</td>
<td>3–4 mo.</td>
<td></td>
<td>4–5 yr.</td>
<td>6–7 yr.</td>
<td>10 yr.</td>
</tr>
<tr>
<td>Cuspid</td>
<td>4½ mo.</td>
<td></td>
<td>6–7 yr.</td>
<td>9–10 yr.</td>
<td>12–14 yr.</td>
</tr>
<tr>
<td>First bicuspid</td>
<td>1½–2 yr.</td>
<td></td>
<td>5–6 yr.</td>
<td>10–12 yr.</td>
<td>12–13 yr.</td>
</tr>
<tr>
<td>Second bicuspid</td>
<td>2½–2½ yr.</td>
<td></td>
<td>6–7 yr.</td>
<td>11–12 yr.</td>
<td>13–14 yr.</td>
</tr>
<tr>
<td>Mandibular</td>
<td></td>
<td></td>
<td>2½–3 yr.</td>
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<td></td>
<td>7–8 yr.</td>
<td>11–13 yr.</td>
<td>14–15 yr.</td>
</tr>
<tr>
<td>Third molar</td>
<td>8–10 yr.</td>
<td></td>
<td>12–16 yr.</td>
<td>17–21 yr.</td>
<td>18–25 yr.</td>
</tr>
</tbody>
</table>

The following factors (Harvey 1976) may influence the determination of age by dental means:

a. Appearance of tooth germs
b. Earliest detectable trace of mineralisation
c. Degree of completion of the unerupted tooth
d. Rate of formation of enamel and formation of the neonatal line
e. Dates of emergence of tooth crowns in oral cavity
f. Degree of completion of the roots of erupted teeth
g. Degree of resorption of the roots of deciduous teeth
h. Attrition of the crown
i. Formation of the physiologic secondary dentine
j. Formation of cementum
k. Transparency of root dentine
l. Gingival recession
m. Root surface resorption
n. Discolouration and staining of the teeth
o. Changes in the chemical composition of the teeth
p. Influence of disease or malnutrition on tooth eruption
q. Influence of sex on tooth eruption

Several methods have been proposed by which the age of the person can be estimated through examination of individual teeth. Most of these methods require removal of the teeth from the jaw and sectioning of these teeth in preparation for microscopic examination. These methods, however, destroy a portion of the evidence and also require specialised apparatus and experienced personnel. One method is based on the development of incremental lines or striations. This may provide a basis for determining the age and may provide evidence of periods of illness and chemicals ingested such as tetracycline, lead, strontium and fluorine (Cameron, Sims 1973).

Gustafson (1950) developed a system of dental age determination using six dental factors known to change with advancing age (Figure 13). They are:

a. Attrition
b. Parodontosis
c. Secondary dentine
d. Cementum apposition
e. Root resorption
f. Transparency of root
Attrition takes place from the wearing down of the incisal or occlusal surfaces mainly due to mastication. Paradontosis is characterised by changes in the attachment of the tooth resulting in exposing the root leading to loosening and exfoliating of the teeth. Secondary dentine may develop within the pulp cavity, partly as a direct sign of ageing and partly as a reaction against pathologic conditions like caries. Cementum apposition may take place at the root and around it. The increase in cementum is due to changes in tooth position. Root resorption may involve both cementum and dentine. The resorption areas are characterised by sharp delineated grooves. Transparency of root is the transparency of the apical parts of the root due to mineralisation of the root dentine canals. It is most visible during the grinding of the tooth but is also visible on the unprepared tooth. This transparency is not to be confused with the transparency seen in the crown of the tooth.

Each criterion is variable so that none can be used alone. When more teeth are used, the variability may be reduced. The transparency of root is the more objective criterion because quantitative data can be generated. The different changes are all estimated and expressed in points. The final point value for the changes in a tooth is the sum of the points of all the changes. The total points derived from the analysis of the six conditions is referred to a graph in order to obtain an age estimate of the person. Accuracy of this method of age estimation is within seven years either way.

Over the years, there have been modifications to Gustafson's method in order to have a more accurate means of estimating age. Stott et al (1982) studied the incremental pattern of cementum which is supposedly related to the number of years the individual had lived with accuracy in 95 per cent of cases.
Figure 13  Gustafson's method of age determination.
Source: Gustafson (1966)

Open root orifice  Closed root orifice

$A_0 =$ no attrition  $A_1 =$ attrition within enamel  $A_2 =$ attrition reaching dentin  $A_3 =$ attrition reaching pulp
$S_0 =$ no secondary dentin  $S_1 =$ secondary dentin has begun to form in upper part of pulp cavity  $S_2 =$ pulp cavity is half-filled
$P_0 =$ no periodontosis  $P_1 =$ periodontosis just begun  $P_2 =$ periodontosis along first one-third of root  $P_3 =$ periodontosis has passed two-thirds of root
$C_0 =$ normal layer of cementum laid down  $C_1 =$ apposition a little greater than normal  $C_2 =$ great layer of cementum  $C_3 =$ heavy layer of cementum
$R_0 =$ no root resorption visible  $R_1 =$ root resorption only on small isolated spots  $R_2 =$ greater loss of substance  $R_3 =$ great areas of both cementum and dentin affected

$T_1 =$ transparency is noticeable  $T_2 =$ transparency over apical third of root  $T_3 =$ transparency over apical two-thirds of root
3.5 RACE DETERMINATION

It is rarely possible to make definitive conclusions from teeth alone concerning race as teeth exhibit few distinct racial characteristics. While Krogman (1946) identified the human race into Caucasoid, Negroid and Mongoloid, dental traits may have a higher frequency in one racial group than the other but no trait is found exclusively in any one race. However, a knowledge of racial characteristics is invaluable when one considers the highly mobile societies today. Interbreeding in modern times, however, has led to lessening of differences between the races. Because of intermixing of hereditary characteristics, people may be classified sociologically as belonging to various clearcut races whereas biologically they may be a mixture of many.

While it is impossible to list a series of dental details that provide positive racial identity for a particular subject, Haines (1972) stated that the morphology of the teeth may suggest racial characteristics. His noted that:

a. 35 per cent of the Aleutian population has a rare condition of taurus mandibularis - a bony outgrowth of the lower jaw near the roots of the canines and the premolars.

b. 95 per cent of the Americans Indians, 46 per cent of Palestinian Arabs and 91 per cent of the Chinese have shovel-shaped incisors.

c. Australian Aboriginals have the largest teeth among those in living races and edge-to-edge bite is common.

d. Taurodontism is common in South African Australoid and the Boskopoid races.

e. Three-rooted molars are common in the Chinese but rare in the Europeans. Many Europeans have narrow arches and crowded teeth.

f. Taurus palatinus is common in Eskimos and occurs in 44 per cent of Icelandic skull.

g. Whites in the United States tend to seek natural-looking anterior restoration while some races favour gold shell crown. Stainless steel and semi-precious alloys are common in central Europe. Undoubtedly, certain dental restoration indicate their country of origin.
3.6 SEX DETERMINATION

It is quite difficult to use the characteristics of teeth and jaws to definitely indicate the sex of the deceased. Although teeth are largely composed of hard tissues, the pulp and the supporting tissues around it are cellular in nature. Removal of a few cells from either the cemental external surface of the tooth or preferably from inside the pulp chamber will usually provide enough tissue for sex determination to be made. Isolation of a Y chromosome in the nucleus of dental pulp cells up to the fifth month post extraction or post-mortem is indicative of a male (Whittaker, Llewelyn, Jons 1975). This method is applicable to a single tooth. The X chromosomes of the Barr body of the female in the buccal mucosa epithelial cells and leucocytes has been used in clinical cases of questioned sex such as Klinefelter's syndrome.

3.7 OTHER IDENTIFYING FACTORS

3.7.1 Cheiloscopy

Cheiloscopy refers to the utilisation of lip prints as a means of personal identification in much the same manner as fingerprints. The Japanese have classified lip prints into 8 patterns which apparently are unique to the individual. Of these, vertical, branched, intersected and reticular are most commonly found (Tsushiihashi 1974). Minor differences can be noted between left and right sides and upper and lower lips. Lip prints can be traced on drinking glasses, facial tissues and clothing.

3.7.2 Rugoscopy

The morphology of the palatal rugae may be sufficiently characteristic of the individual for identification purposes. The pattern will presumably reappear even if surgically removed or damaged by chemicals or disease (Basauri 1961 cited by Harvey 1976). Men have better developed rugae than women. The palatal rugae can be used to confirm the ownership of upper denture or even denture fragments since the reverse image of the rugae are reproduced on the palatal surface. Comparison is usually accomplished using ante-mortem impressions made for study models or prosthodontic consideration.
3.8 THE ANTE-MORTEM DENTAL DATA

The ante-mortem dental data which are of interest include: written dental records, dental radiographs, study models, prosthetic appliances and photographs (especially those photographs that show prominent anterior teeth, a 'toothy' photograph).

3.8.1 The ante-mortem dental record

Ante-mortem dental charts in use today come in various colours, shapes, sizes and forms. In America alone more than 150 (Mertz 1977), or 40 (Ahlberg 1987), different types were in regular use. Completeness and accuracy of all the details is seldom found in either military or civilian records (Hill 1985, Alexander 1991). For example, fillings not done by the dentist himself and other conditions not requiring treatment are seldom recorded. Most dental charts combine some form of diagrammatic charting of the dentition (odontograms) with a symbolic description of the treatment rendered.

Radiographs are the most objective type of dental record that can be found and provide not only a great deal of additional data but serve to correct any recording errors in the written abbreviations that dentists use to record dental information on a chart, and this may be a critical factor (DeVore 1977). Care must therefore be taken when transposing information from the original ante-mortem dental record especially when the x-ray is not dated.

It is helpful to convert ante-mortem dental data to a common form of charting system as in the Dental Identification Form 'A' of FDI format of the dental status of missing person (Appendix III) or to Form 'i' approved by Interpol (Appendix IV) where one may make a rapid comparison of ante-mortem and post-mortem dental data recorded in the FDI format or the approved format by Interpol for decayed, missing, filled or restored teeth as well as other important details.
3.8.2 Relationship to the post-mortem dental record

Positive identification of an unknown human remains requires the availability of ante-mortem records for comparison with the post-mortem records. Occasionally the ante-mortem dental records are not available at the time the dentist is required to begin his investigation. It should be emphasised that one rarely finds a perfect match between the ante-mortem and post-mortem dental data. This can be most commonly attributed to the dentist who only charts (ante-mortem) the existing caries and those restoration which they personally place.

3.8.3 Securing the ante-mortem dental record

The starting point in the search for ante-mortem dental records is the mane of the individual who might be involved. Ante-mortem dental records and their sources vary almost as much as the charts. Naturally the first consideration in securing these records is to discover who might have examined or completed dental work on the person. The likelihood that the unidentified individual had been seen by more than one dentist during his life time must not be overlooked. The family should be questioned regarding previous dentists seen who might include:

a. Paedodontist
b. Periodontist
c. Orthodontist
d. Oral surgeon
e. Hospital/dental clinic
f. Military service
g. Family dentist

A less reliable source would be a recollection of family members or the dentist of individual dental traits of the deceased.
4 CORRELATION OF DENTAL DATA - ANTE AND POST-MORTEM

The aim of correlating the ante-mortem and post-mortem dental data is to examine the data on the same jaw sector, single tooth or tooth surfaces for points of concordance.

4.1 COMPARISONS OF ANTE-MORTEM AND POST-MORTEM DENTAL RECORDS

After consolidating the ante-mortem dental data onto a chart similar to the post-mortem dental record, a comparison can take place. Only rarely does one find a perfect match of the records. Most commonly, the ante-mortem dental chart will show only existing caries and other work to be performed or what the dentist personally performed. The more alterations or abnormalities that exists in a given mouth, the greater are the potential points of comparison. A positive identification must have no incompatibility and inconsistencies must be resolved to effect a perfect match between the ante-mortem and post-mortem dental data.

4.2 DENTAL RADIOGRAPHIC COMPARISONS

Radiographic evaluation of teeth and bones is extremely valuable for positive examination and comparison (Figure 14). For identification purposes, properly exposed, developed, mounted and labelled dental radiographs are as good, if not better than, fingerprints. Among features revealed by both extra-oral and intra-oral radiographs that are impossible or inconvenient to assess visually are the following (Luntz and Luntz 1973):

a. Direct comparison between ante-mortem and post-mortem radiographs
b. Tooth shape and inclination in the socket
c. Extent of caries and periodontal disease
d. Impacted and unerupted teeth
e. Nature of crown and extent of restorations such as root fillings and post crowns
f. Fractures and their treatment - pins, wires or plates
g. Verification of original position and designation of teeth adjoining extraction sockets

In some instances, a single tooth may be all that remains and upon radiographic comparison, a positive identification can be made (DeVore 1977). Caution must be exercised if ante-mortem panoramic radiographs were to be used to compare with post-mortem periapical or bitewing films for bone details and restoration size and shape as inherent distortion characteristics can be found in panoramic radiograph. Panoramic films (Figure 15) are particularly useful for an overall view of teeth and jaws as the films show in general bony changes and fractures though they lose the details and sharpness of the small intra-oral films.
The Department of Forensic Medicine, University of Turku, Finland reviewed cases where radiological methods were used for identification in the medicolegal autopsy (Happonen 1991). Radiographs of the head were used in the identification of 17 victims where all but one had adequate dental records available. Radiographic examinations resulted in a positive identification of 10 victims, 4 were based on exclusion, 2 remain unidentified by radiological methods and in 1 case, there was comparable information supporting the identity. The radiological methods used in identification are summarised in Table 4.

### Table 4  Summary of the radiological methods used in identification of 17 victims in 13 accidents.

**Source: Happonen (1991)**

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Radiological ID / No of victims</th>
<th>Ante Mortem Radiographs available</th>
<th>Post Mortem Radiographs used</th>
<th>Criteria used for identification</th>
<th>Other comments</th>
<th>Conclusion of identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire</td>
<td>1/1</td>
<td>Lateral and AP skull</td>
<td>Lateral and AP skull</td>
<td>Vascular grooves of skull vault, shape of frontal sinus</td>
<td>DR available</td>
<td>Positive</td>
</tr>
<tr>
<td>Fire</td>
<td>1/26</td>
<td>AP skull</td>
<td>Frontal sinus</td>
<td>Shape of frontal sinus</td>
<td>DR not available</td>
<td>Positive</td>
</tr>
<tr>
<td>Fire</td>
<td>1/1</td>
<td>2 BW, 1 IO</td>
<td>2 BW, 1 IO</td>
<td>Dental fillings, root canal therapy</td>
<td>DR available</td>
<td>Positive</td>
</tr>
<tr>
<td>Drowning</td>
<td>1/1</td>
<td>2 BW, 2 IO OPG</td>
<td>2 BW, 1 IO OPG</td>
<td>Dental fillings, root therapy, retained wisdom tooth</td>
<td>DR available</td>
<td>Positive</td>
</tr>
<tr>
<td>Fire</td>
<td>1/1</td>
<td>None</td>
<td>2 BW, 4 IO OPG</td>
<td>DR</td>
<td>Incomplete DR</td>
<td>Supporting, no incompatibilities</td>
</tr>
<tr>
<td>Drowning</td>
<td>1/1</td>
<td>2 BW</td>
<td>4 IO, OPG</td>
<td>Dental bridges</td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>Fire and Explosion</td>
<td>1/1</td>
<td>None</td>
<td>4 IO, 3 Ocul</td>
<td>DR</td>
<td>Incomplete DR</td>
<td>ID not possible, no incompatibilities</td>
</tr>
<tr>
<td>Fire</td>
<td>4/7</td>
<td>None</td>
<td>2 BW</td>
<td>Dental fillings, root canal therapy</td>
<td>DR available</td>
<td>Positive</td>
</tr>
<tr>
<td>Fire</td>
<td>1/1</td>
<td>None</td>
<td>2 BW</td>
<td>DR</td>
<td>Child, DR avail</td>
<td>Exclusion ID</td>
</tr>
<tr>
<td>MVA, Fire</td>
<td>2/2</td>
<td>None</td>
<td>2 BW</td>
<td>DR</td>
<td>Mand missing,</td>
<td>Exclusion ID</td>
</tr>
<tr>
<td>Suffocation</td>
<td>1/1</td>
<td>OPG</td>
<td>OPG</td>
<td>Persistent maxillary deciduous cuspid, anatomy of teeth</td>
<td>Full dentition, no dental fillings done, DR available</td>
<td>Positive</td>
</tr>
<tr>
<td>Car fire</td>
<td>1/1</td>
<td>2 BW</td>
<td>4 IO</td>
<td>Dental fillings</td>
<td>2 fragments of jaws &amp; 4 teeth left, DR avail</td>
<td>ID not possible no incompatibilities</td>
</tr>
<tr>
<td>Drowning</td>
<td>1/1</td>
<td>OPG</td>
<td>OPG</td>
<td>Dental fillings</td>
<td></td>
<td>Positive</td>
</tr>
</tbody>
</table>

Radiographs used: AP anteroposterior; DR dental records; BW bitewing; IO intraoral; OPG orthopantomograph; Ocul occclusal
Comparison of the ante-mortem bitewing radiograph (A) and the post-mortem bitewing (B) confirmed the identification. Observe the numerous matching details in the two radiographs.
Figure 15  OPG (ante- and post-mortem) of an edentulous person and points of concordance.
Source: Courtesy of Dr Chris Griffiths (1991)
4.3 USE OF COMPUTER FOR IDENTIFICATION

"Computers are certainly more efficient than men at some tasks but those tasks and their solution must be definable by the human minds behind the computer algorithms. Where a computer programme is not efficient, it is almost always the human intellect behind the programme that has failed to understand the problem completely." (Friedman et al 1989).

Computer-assisted identification involves the application of computer technology to the identification process. It effectively stores, retrieves, and analyses large amounts of data and it can quickly and accurately execute complex mathematical and logical operations. In computer-assisted identification, these data handling capabilities are merged with algorithms to ideally produce possible outcomes of equal or greater accuracy when compared with those done by forensic dentists.

The first computer-assisted dental identification in America was during the Big Thompson Canyon flood in Colorado in 1976 where 139 bodies were recovered and identified (Baker 1982). Pierce et al of Northwestern University Dental School, Chicago in 1982 attempted to developed a computer-assisted programme for positively identifying human remains. This system uses screen graphics to show the charting; this proved useful in explaining to relatives of the deceased how an identification was made. A second generation computer code was produced after modification of the first generation code and programme. This was as a result of the findings of a preliminary study.

Cohen et al (1983) devised a comparison method that used partial post-mortem dental data to aid in the final identification. They used a few easily recorded measurements involving restorations and missing teeth in the posterior region. Using this system, the computer generated an ordered list of possible matches for each post-mortem dental record.
Cohen et al (1983) listed three possibilities that can exist:

a. If a restoration at a particular tooth surface (filled, FS) or a missing tooth (MT) occur at both ante-mortem and post-mortem records, it is considered as a HIT.

b. A modified (MOD) situation may occur given a reasonable time interval between the collection of ante-mortem and post-mortem data. For example an FS or MT may be present in the victim but absent in the ante-mortem data.

c. A logical impossibility (IMP) arises when an FS or MT may be present in the match but a tooth or sound surface may be found in the victim.

Cohen did not quantify the third molars due to variability of the tooth itself. He concluded that his proposed system does not preclude positive identification being made by the forensic dentist but however, does decrease the information load a forensic specialist must carry during the earlier stages of record matching.

4.3.1 Computer-assisted post-mortem identification (CAPMI) system

The US Army Institute of Dental Research (USAIDR) in 1983 developed the CAPMI system as a means to improve forensic science examiner efficiency by relegating aspects of repetitive chart-to-chart comparisons of ante-mortem and post-mortem records to a computer (Lorton, Langley 1986). Both dental and non dental characteristics are compared to produce lists of the most probable ante-mortem and post-mortem record matches. The system can sort 1,200 to 5,000 records a second (Jakush 1989). The CAPMI system was also designed to permit eventual integration of all pertinent data into a comprehensive database of electronically stored dental records to be constructed at the time of each service member’s entry into the military and to be updated routinely thereafter. The CAPMI system employs the Universal system of tooth designation. The dental portion of the database consists of fields for each permanent tooth numbered according to the Universal notation system. Any combination of mesial (M), occlusal (O), distal (D), filled (F), missing (X), crown (C) or unerupted (U) plus other modification like pontic (PON), root canal therapy (RCT) or a coded dental restorative material may be added. Decayed surfaces are not used as sorting factors as these are subject to clinical and radiographic judgment (Lorton, Rethman, Friedman 1988).

The subsequent comparison of the ante-mortem and post-mortem dental data will result in one of three possible outcomes for tooth-for-tooth comparison; a "match", a "possible" or a "mismatch" which is similar to Cohen et al HIT, MOD and IMP respectively.
There are four situations in which an identity search might be considered:

a. A large ante-mortem population of records and a small or large number of post-mortem remains as in a mass disaster

b. A large ante-mortem database and a few post-mortem remains as in searching a missing persons file

c. A small ante-mortem database and a large number of fragmented post-mortem remains. An example was the air crash in Poland in 1987 with 183 passenger and crew aboard. The post-mortem remains were mainly in fragments and the ante-mortem records incomplete. In this case the CAPMI software was altered and tallies of mismatches were found to be more effective. This resulted in the necessary software changes being made

d. A small number of post-mortem remains and a correspondingly small number of ante-mortem records. In this case, computerised aid was of little value since the memory and logic requirements for such a task are within the capabilities of human recall

4.3.2 'IDENTIC' system

Arneman (1991) is developing a computer programme designed to carry out the bulk sorting of the post-mortem and ante-mortem dental records. The programme called 'IDENTIC' currently is able to compare one post-mortem data to 50 ante-mortem dental data a second. The computer codes are structured to allow comparison without accidentally eliminating teeth of questionable status. The computer comparison mask codes in current usage are simple as all teeth are considered. The codes used include:

a. A Tooth absent ante-mortem
b. P Tooth present
c. T Tooth treated - the type of treatment and material used is not considered
d. U Unknown status - used only for ante-mortem where no details are known
e. R Tooth absent post-mortem
f. Z Tooth present but status is unknown - use only for post-mortem when a tooth is known to be present but there are no details

Other module options for comparison are sex and age group searches, personal data information and single feature cross-matching. IDENTIC employs the FDI two-digit system of tooth designation.
Comparing the two computer systems (CAPMI and IDENTIC), it is apparent that the IDENTIC programme is simpler and easier to understand by someone who is new to the programme since it did not have the various combination of treated surfaces and restoration to be coded into the post-mortem dental data.

The use of computer technology would certainly decrease the time and costs for the identification process. Since identification is a result of reasoning and logic, computers act as a sorting tool and not a method to identify victims positively. Computer matching does not obviate the need for ante-mortem and post-mortem dental records examination and final identification by a forensic dentist. Computer assistance helps to narrow down the number of possible persons for more detailed matching of records.

Dorion (1990) stated that the need for computer use in disaster situations is determined by:

a. Size of the disaster - the number of victims
b. The number of specimens - fragmentation of each victim
c. The condition of the specimen - fresh, decomposed or skeletonised
d. The local conditions - work force, locus, accessibility, climatic conditions and space
e. The accessibility to hardware and software
4.4 IDENTIFICATION VERIFICATION

The final decision as to the correctness or degree of credibility of the identification rests within the judgement and experience of the forensic dentist. There is no minimum number of points of concordance accepted as necessary to make a positive dental identification. A single tooth fragment or a single dental radiograph can permit a positive identification (Kelser-Nielsen 1980, Sopher 1976). The quality and uniqueness of the points and the total circumstances of the identification situation must also be considered (Cottone 1982).

The degree of certainty in the identification of unknown bodies can be categorised, according to Dorion (1990), as follows:

a. **Positive.** The ante-mortem and post-mortem data match in sufficient details quantitatively and qualitatively to establish that they are from the same individual. All changes that have taken place during the course of the treatment are taken into account. In addition, there are no irreconcilable discrepancies

b. **Probable.** The ante-mortem and post-mortem data have consistent features but, due either to the condition of the remains or the quality of the ante-mortem evidence, it is not possible to positively establish dental identification

c. **Possible.** The difference between probable and possible is a question of degree, the former being stronger

d. **Insufficient evidence.** The available data is insufficient to form the basis for a conclusion

e. **Elimination.** The data is clearly inconsistent

Cottone (1982) categorised tooth-to-tooth comparisons between ante-mortem and post-mortem data as follows:

a. **Identical.** The condition of teeth in the post-mortem record is the same as that of the ante-mortem record

b. **Consistent.** The condition of the teeth in the post-mortem record may have evolved from conditions recorded in the ante-mortem record

c. **Inconsistent.** The condition of the teeth in the post-mortem record is not consistent with that in the ante-mortem record

Cottone's categorisation is in accord with that of Cohen et al's (1983) **HIT, MOD, IMP** and Lorton et al's (1988) **match, possible and mismatch** for computer-aided identification.
4.5 FORENSIC DENTAL REPORT ON THE OUTCOME OF THE COMPARISON.

A professional expert is a person who, upon request, places his particular professional knowledge at the disposal of those requesting his services, but who leaves it to the latter to draw any legal conclusions from his findings (Cameron and Sims 1973).

Upon completion of the examination, the forensic dentist has to submit a report of his findings, although this is not always required. The report should state the date, time and place of the examination, and details of the procedures and personnel who participated in the examination. His report should include the degree of certainty of identification. It could state that the identification was "identical/positive", "consistent", or that the findings were "inconsistent with the ante-mortem records of the deceased" and it should include the basis for the conclusion. If dental identification is achieved, clear reference must be made to all material used in the comparison: the dental post-mortem report; the ante-mortem report; the expert's own comparison sheet and the 'dental identification report' (Keiser-Nielsen 1980).

A statement from the dentist is useful to the medical examiner or the coroner who will attest to the death of an individual (Jerman 1981).

In summary, the real strength of any evidence in court lies in its reasonableness; it must be sound and defensible, and must appear so to the judges. Opinions should be based on facts and identification or otherwise must be positive beyond any doubt (Ashkinazi 1989).
5 PROBLEMS DURING THE IDENTIFICATION PROCESS

The problems that may be encountered during the course of identifying the remains through dental characteristics include:

a. Different charting systems used ante-mortem
b. Nature and quality of ante-mortem dental records
c. Pinking of tooth
d. Fragmentations of dental evidence
e. Identification after burning

5.1 DENTAL CHARTING SYSTEMS

The basic purpose of all dental charting system is to indicate by using some symbols the location of each tooth in the dental array. There are many different forms of dental charts being use throughout the world (Frykholm and Lysell 1962, Mertz 1977, Ahlberg 1988). Problems would certainly arise in interpreting the various symbols and abbreviations in the charts. A dentist can often decide from the context with reasonable certainty which tooth is meant. However, in the field of forensic dentistry, where speed and absolute reliability is essential, these ambiguity may complicate the process. In the New Orleans crash of 1982, for example where 154 victims came from 15 different countries and one dental record contained nine different types of dental charting (Dorion 1990).

In order to prevent the dental records from becoming too bulky and unwieldy, normally all dentist described or enter their findings and treatment in an abbreviated or codified form or have them in pictorial forms/odontograms (Figure 16) which differ from one another even though they contain the same information.

Frykholm and Lysell in 1962 published a comprehensive review of a dozen dental notation systems that were used in the 1950s in 35 countries. They concluded that the great majority of systems fall into two categories: those having similar notation for each teeth in each segment, and those having a different notation. Each system was originally intended to designate the permanent teeth but later, a complementary system for the temporary dentition was established, often by addition to the symbols used in the basic.
Figure 16
Examples of odontograms

Odontogram using the FDI two-digit system

Example of an odontogram from the University of Malaya, Malaysia (Palmers Notation system)

Odontogram of the Malaysian Government Dental Service (FDI two-digit system)
Different types of odontograms (continued)

Odontograms using the Universal system

Odontogram using the Navy system

Odontogram using the Army system
The submission for a two-digit system of tooth designation by Dr Jochen Viohl of Berlin (who had been using it for sometime) in 1970 to the Council's Special Committee on Uniform Dental Recording at the FDI General Assembly in Bucharest, Rumania was well received (FDI 1971). The Committee proposed that the system be adopted worldwide and the Assembly resolved the resolution by thirty (38) votes in favour, eleven (11) against and seven (7) abstained. Since the forensic dentist should have a working knowledge of the various systems and for the purpose of this thesis, the various systems will be discussed.

5.1.1 Dental notation systems used for registering teeth

A. Systems having a similar notation in each segment

System 1

The oldest known method is probably the Zsigmondy's System. The system is very widespread throughout the world (Europe, America (North, Central and South), Australia and Japan). In the English-speaking countries, it is generally known as Palmer's Notation. The system relies on a grid placed around the tooth in question to indicate left or right and upper or lower. The medial or central incisor of each segment is given the number '1' and the numbers then run in a distal direction. The segments are shown by the symbols [ ] [ ] and [ ] for the patient's upper right, upper left, lower left and lower right segments respectively. The permanent dentition are assigned numbers from 1 to 8 whilst the deciduous dentition are assigned alphabets from 'A to E' or 'a to e'. Sometimes the letter 'D/d' for deciduous or 'm' is placed after the number of the tooth.

Permanent dentition

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<tr>
<th></th>
<th>8 7 6 5 4 3 2 1</th>
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<td></td>
<td></td>
</tr>
<tr>
<td>lower</td>
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<td>1 2 3 4 5 6 7 8</td>
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Variations for the deciduous dentition

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<td>1D 2D 3D 4D 5D</td>
</tr>
<tr>
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<td>5D 4D 3D 2D 1D</td>
<td>1D 2D 3D 4D 5D</td>
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<td>d1 d2 d3 d4 d5</td>
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<tr>
<td>d5</td>
<td>d4 d3 d2 d1</td>
<td>d1 d2 d3 d4 d5</td>
</tr>
</tbody>
</table>
System 2

This system employs both the same angle signs and numerals 1 to 8 for enumerating the permanent teeth and 'A to E' for deciduous teeth but it is the exact opposite of system 1. The notation is as follows.

\[
\begin{array}{cccccccc|cccccccc}
\text{upper} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & A & B & C & D & E & E & D & C & B & A \\
\text{lower} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & A & B & C & D & E & E & D & C & B & A \\
\end{array}
\]

System 3

Other angle systems do not make use of numerals but designate the teeth from the mesial incisor: I₁, I₂, C, P₁, P₂, M₁, M₂, M₃

i.e., the initial letters of their respective Latin names. The temporary teeth are in lower case, sometimes supplemented with the letter 'd' placed before the letter symbol. The system is employed mainly in Holland.

Permanent dentition

\[
\begin{array}{cccccccc|cccccccc}
\text{upper} & R & M₃ & M₂ & M₁ & P₂ & P₁ & C & I₂ & I₁ & I₁ & I₂ & C & P₁ & P₂ & M₁ & M₂ & M₃ & L \\
\text{lower} & R & M₃ & M₂ & M₁ & P₂ & P₁ & C & I₂ & I₁ & I₁ & I₂ & C & P₁ & P₂ & M₁ & M₂ & M₃ & \end{array}
\]

Deciduous dentition

\[
\begin{array}{cccccccc|cccccccc}
\text{upper} & R & dm₂ & dm₁ & dc & di₂ & di₁ & di₁ & di₂ & dc & dm₁ & dm₂ & dm₂ & dm₁ & dc & di₂ & di₁ & dm₁ & dm₂ & L \\
\text{lower} & R & dm₂ & dm₁ & dc & di₂ & di₁ & di₁ & di₂ & dc & dm₁ & dm₂ & dm₂ & dm₁ & dc & di₂ & di₁ & dm₁ & dm₂ & \end{array}
\]
System 4

This system uses the same designation as in system 3, i.e. the incisors (I), canines (C), premolars (P) and molars (M) are indicated in the following way: I₁, I₂, C, P₁, P₂, M₁, M₂, M₃ but without the use of angle signs. The upper jaw is indicated by the letter 's' (superior) and the lower by 'i' (inferior) placed immediately after the index numeral and followed by 'd' or 's' (dexter/right, sinister/left respectively). For the primary teeth, lowercase letters are used. The system is used in Holland.

Permanent dentition

```
   R    L
upper  M₃sd M₂sd M₁sd P₈sd P₇sd C₈sd I₇sd I₆sd  I₁ss I₂ss C₈ss P₁ss P₂ss M₁ss M₂ss M₃ss
lower  M₃ld M₂ld M₁ld P₈ld P₇ld C₈ld I₇ld I₆ld  I₁ls I₂ls C₈ls P₁ls P₂ls M₁ls M₂ls M₃ls
```

Deciduous dentition

```
   L
upper  m₃sd m₂sd c₈sd i₇sd i₆sd  i₁ss i₂ss c₈ss m₁ss m₂ss
lower  m₃ld m₂ld c₈ld i₇ld i₆ld  i₁ls i₂ls c₈ls m₁ls m₂ls
```

System 5

Very similar to the above is the system having the same letter and index numeration for the teeth, but where the segment is indicated by the position of the index in relation to the alphabetical letter of the tooth as in ³M, M³ for the upper right and upper left third molar respectively and ³M, M₃ for the lower right and lower left third molar respectively. The system is employed in South Africa.

```
   R    L
³M ²M ¹M ²P ¹P ¹C ²I ¹I 1₁ 1₂ C¹ P¹ P² M¹ M² M³
³M ²M ¹M ²P ¹P ¹C ²I ¹I 1₁ 1₂ C¹ P₁ P₂ M₁ M₂ M₃
```
System 6

In this system, the teeth are numbered 1-8 from the medial incisor in a distal direction. The teeth in upper jaw are indicated by a capital ‘D’ (for droite/right) or ‘G’ (for gauche/left) immediately in front of the number of the tooth. The teeth in the lower jaw are indicated by a small ‘d’ or ‘g’. This system is limited in France and Rumania.

<table>
<thead>
<tr>
<th>upper</th>
<th>D8</th>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower</td>
<td>d8</td>
<td>d7</td>
<td>d6</td>
<td>d5</td>
<td>d4</td>
<td>d3</td>
<td>d2</td>
<td>d1</td>
<td>g1</td>
<td>g2</td>
<td>g3</td>
<td>g4</td>
<td>g5</td>
<td>g6</td>
<td>g7</td>
<td>g8</td>
</tr>
</tbody>
</table>

System 7

This system uses the (+) and (-) signs and is called after its inventor, Haderup. The system was once practically the only one used in Sweden, Denmark, Norway, Finland and Iceland. Along with other systems, it was also used in Germany, Italy, Switzerland, Yugoslavia, Poland and Czechoslovakia. The teeth are numbered in the same way but a plus (+) sign is placed before or after a maxillary tooth to indicate the upper left or right quadrants, and a minus (-) sign is similarly used for the mandibular teeth. These signs are placed to the right of the numeral if the tooth is situated in the right side of the jaw, and to the left of the numeral if the tooth is situated in the left side of the jaw.

For the deciduous dentition, it uses the numbers (1 to 8) and a zero is placed between the tooth number as 03+, +03, 03-, -03 for the upper right canine, upper left canine, lower right canine and lower left canine respectively. The system is as follows:

Permanent dentition

<table>
<thead>
<tr>
<th>R</th>
<th>8+</th>
<th>7+</th>
<th>6+</th>
<th>5+</th>
<th>4+</th>
<th>3+</th>
<th>2+</th>
<th>1+</th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th>+4</th>
<th>+5</th>
<th>+6</th>
<th>+7</th>
<th>+8</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>8-</td>
<td>7-</td>
<td>6-</td>
<td>5-</td>
<td>4-</td>
<td>3-</td>
<td>2-</td>
<td>1-</td>
<td>-1</td>
<td>-2</td>
<td>-3</td>
<td>-4</td>
<td>-5</td>
<td>-6</td>
<td>-7</td>
<td>-8</td>
</tr>
</tbody>
</table>

Deciduous dentition

<table>
<thead>
<tr>
<th>R</th>
<th>O5+</th>
<th>O4+</th>
<th>O3+</th>
<th>O2+</th>
<th>O1+</th>
<th>+O1</th>
<th>+O2</th>
<th>+O3</th>
<th>+O4</th>
<th>+O5</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>O5-</td>
<td>O4-</td>
<td>O3-</td>
<td>O2-</td>
<td>O1-</td>
<td>-O1</td>
<td>-O2</td>
<td>-O3</td>
<td>-O4</td>
<td>-O5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R</th>
<th>V+</th>
<th>IV+</th>
<th>III+</th>
<th>II+</th>
<th>I+</th>
<th>+I</th>
<th>+II</th>
<th>+III</th>
<th>+IV</th>
<th>+V</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>V-</td>
<td>IV-</td>
<td>III-</td>
<td>II-</td>
<td>I-</td>
<td>-I</td>
<td>-II</td>
<td>-III</td>
<td>-IV</td>
<td>-V</td>
</tr>
</tbody>
</table>
System 8 or FDI two-digit system (Sandham 1983, Elderton 1989)

Every tooth in both the permanent and deciduous dentition is given a number, maintaining the same Zsigmondy / Palmer sequence from the central incisor distally to the third molar, i.e. #1 to #8. However, each quadrant is given a separate number so that the upper right quadrant is numbered 1, upper left quadrant is numbered 2, lower left quadrant numbered 3 and lower right quadrant is numbered 4. For the deciduous dentition, the upper right quadrant becomes quadrant 5, upper left quadrant becomes quadrant 6, lower left quadrant becomes quadrant 7 and lower right quadrant becomes quadrant 8. Thus, 11 (read as one-one) is the permanent upper right central incisor and 51 (five-one) is the deciduous upper right central incisor.

Permanent dentition

<table>
<thead>
<tr>
<th></th>
<th>right</th>
<th>left</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper</td>
<td>18 17 16 15 14 13 12 11</td>
<td>21 22 23 24 25 26 27 28</td>
</tr>
<tr>
<td>lower</td>
<td>48 47 46 45 44 43 42 41</td>
<td>31 32 33 34 35 36 37 38</td>
</tr>
</tbody>
</table>

Deciduous dentition

<table>
<thead>
<tr>
<th></th>
<th>right</th>
<th>left</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper</td>
<td>55 54 53 52 51</td>
<td>61 62 63 64 65</td>
</tr>
<tr>
<td>lower</td>
<td>85 84 83 82 81</td>
<td>71 72 73 74 75</td>
</tr>
</tbody>
</table>
B. Systems with different notation in each segment

In the USA where, apart from those already mentioned, several systems employing different notation for the teeth in the different segments are in use. The most common of these are probably those styled, formerly at least, the 'Army System', the 'Navy System', the Universal System', and the 'Bosworth System'.

System 9 - The Army System and its variant

Permanent dentition

| Upper | 8 7 6 5 4 3 2 1 | 1 2 3 4 5 6 7 8 |
| Lower | 16 15 14 13 12 11 10 9 | 9 10 11 12 13 14 15 16 |

Deciduous dentition

| Upper | E D C B A | A B C D E |
| Lower | J I H G F | F G H I J |

System 10 - The Navy System and its variant

Permanent dentition

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

Variations for the deciduous dentition

| Upper | I II III IV V | VI VII VIII IX X |
| Lower | XI XII XIII XIV XV | XVI XVII XVIII XIX XX |
| Upper | A B C D E | F G H I J |
| Lower | K L M N O | P Q R S T |
System 11 - The Universal System
This system gives each permanent tooth a number starting with the upper right third molar as #1. The teeth are numbered around the upper arch, then around the lower arch ending with the lower right third molar as #32. For the deciduous teeth, they are labelled A-T using the above order, so that the upper right deciduous canine is represented by C and the upper deciduous right lateral incisor by D. A variation is to record the deciduous teeth as 1-20 in the same order as the permanent but a ‘D’ is placed against each number so that the deciduous right second molar becomes D1.

The system uses the Arabic numbers 1 to 32 for permanent teeth and alphabets A-T or D1 to D20 for deciduous teeth.

### Permanent dentition

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

### Deciduous dentition

<table>
<thead>
<tr>
<th>(R)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower</td>
<td>T</td>
<td>S</td>
<td>R</td>
<td>Q</td>
<td>P</td>
<td>O</td>
<td>N</td>
<td>M</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(R)</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6</th>
<th>D7</th>
<th>D8</th>
<th>D9</th>
<th>D10</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower</td>
<td>D20</td>
<td>D19</td>
<td>D18</td>
<td>D17</td>
<td>D16</td>
<td>D15</td>
<td>D14</td>
<td>D13</td>
<td>D12</td>
<td>D11</td>
</tr>
</tbody>
</table>

Sometimes the letter is placed after the numeral.

System 12
This system is used mainly in Cincinatti, USA which is the mirror image of the Navy System. The temporary teeth are indicated by placing the letter ‘D’ before the number of the corresponding permanent tooth.

| \(R\) | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | L |
|------|----|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|
| lower | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 |
System 13 - The Bosworth System

This system used numbers to represent the upper dentition and alphabetic letters for the lower dentition for the permanent dentition and the letter ‘D’ is placed before the numbers or alphabets for the deciduous dentition.

Permanent dentition

<table>
<thead>
<tr>
<th>Upper</th>
<th>8 7 6 5 4 3 2 1</th>
<th>1 2 3 4 5 6 7 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>R</td>
<td>H G F E D C B A</td>
</tr>
</tbody>
</table>

Deciduous dentition

<table>
<thead>
<tr>
<th>Upper</th>
<th>D5 D4 D3 D2 D1</th>
<th>D1 D2 D3 D4 D5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>R</td>
<td>DE DD DC DB DA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA DB DC DD DE</td>
</tr>
</tbody>
</table>

System 14 - Royal Australian Air Force (RAAF) system

The RAAF system has been devised for telexing numbers. The system uses number 1 for central incisor and 8 for third molar. The system is as follows:

- ‘RTUP’ for right upper (RTUP3 - right upper canine)
- ‘LTUP’ for left upper
- ‘RTL’ for right lower
- ‘LTL’ for left lower

The letters R, S, T, V, W, X, Y, Z represent teeth numbers 1 2 3 4 5 6 7 8 respectively. For example, RTUPT is right upper canine.

System 15 - ANZUS (Australia, New Zealand, and United States) system

This system uses the letters UR, UL LL, LR for the quadrants, i.e. upper right, upper left, lower right and lower right respectively, and is placed in front of the number where 1 is for central incisor and 8 for third molar, and uses ‘A or a’ to ‘E or e’ for the deciduous teeth. The system was commonly used in Australia and New Zealand.

For example, UR1 is upper right central incisor. LL8 is lower left third molar.

UR8 UR7 UR6 UR5 UR4 UR3 UR2 UR1  UL1 UL2 UL3 UL4 UL5 UL6 UL7 UL8
LR8 LR7 LR6 LR5 LR4 LR3 LR2 LR1  LL1 LL2 LL3 LL4 LL5 LL6 LL7 LL8
Since it was first adopted by the FDI General Assembly in 1970, the FDI two-digit system, has been \textit{officially adopted} by various bodies such as the British Standards Institution, International Standards Organisation (ISO), the World Health Organization (WHO) for use in worldwide epidemiological surveys, the International Association for Dental Research, Interpol for international tooth identification, thirteen countries/national dental associations and by dental journals in eighteen countries (Ahlberg 1988). The real figures may be higher as the system has also been adopted by book publishers, dental schools and health insurance organisations. The two-digit system has been introduced in almost the entire developing world and in most industrialised countries except the USA where the American Dental Association adopted the Universal system which had been widely adopted in the country by insurance carriers and others; it objects to the FDI two-digit system (Ahlberg 1988).

The FDI two-digit system has several advantages over the other systems in that:

a. It is simple to teach and to understand
b. It helps to prevent errors when differentiating between left and right sides of the mouth or between upper and lower dental arches
c. In speech, all anatomically similar teeth in different quadrants have the same second digit, so that mention of, say ‘all the sixes’ can be used effectively and simplify descriptive purposes, i.e. it is readily communicable in conversation and dictation
d. It is easy to translate in print, telex as well as being capable of being incorporated in computer language
e. Lastly, it is easy to adapt to standard charts used in general practice

5.1.2 The registration of tooth surfaces

Surfaces of a tooth or localisation of fillings and caries attacks are also expressed in codified form. However, there are fewer different systems than for those used for registration of teeth. System A refers to the different surfaces by using the Latin root for the surfaces (the first letter of the Latin name); system B, uses numerals instead of alphabetic letters; and in system C the surfaces are recorded according to Black’s classification.

<table>
<thead>
<tr>
<th>System A</th>
<th>System B</th>
<th>System C</th>
</tr>
</thead>
<tbody>
<tr>
<td>m (mesial / median)</td>
<td>1 (occlusal)</td>
<td>Black’s Classification:</td>
</tr>
<tr>
<td>o (occlusal / central)</td>
<td>2 (mesial)</td>
<td>I (occlusal/pits/fissures)</td>
</tr>
<tr>
<td>d (distal)</td>
<td>3 (facial)</td>
<td>II (proximal/premolar/molar)</td>
</tr>
<tr>
<td>b (buccal)</td>
<td>4 (distal)</td>
<td>III (proximal, anterior)</td>
</tr>
<tr>
<td>l (lingual)</td>
<td>5 (lingual)</td>
<td>IV (proximo-incisal)</td>
</tr>
<tr>
<td>i (incisal)</td>
<td>6 (cervical)</td>
<td>V (gingival)</td>
</tr>
</tbody>
</table>
In summary, the desirability of correct registration, and its importance, is most obvious for the purpose of identification in forensic dentistry. Thus, correct interpretation of the vast array of symbols, abbreviations and codes used to record dental information may be a critical factor in determining the dental evidences in the identification processes to reduce dangers of unnecessary sufferings due to misidentification or lack of identification of accident/disaster victims.

5.2 NATURE AND QUALITY OF ANTE-MORTEM DENTAL RECORDS

The ante-mortem dental data which are commonly used are the written dental records and dental radiographs. Inadequate written dental records (inavailability, illegibility, inadequate charting of dental status at a fixed point of time i.e. current); and inadequate dental radiographs (availability, quality, orientation and dating) contribute to the problems in dental identification. These problems will continue to exist since many countries have no systematic record keeping and do not regularly utilise dental radiographs.

The importance of intact and accurate ante-mortem dental records has been emphasised by several authors and forensic dental identification has increasingly becoming a favoured method for relatively rapid and reliable victim identification (Smith & Palian 1985, Gillespie et al 1985). The format, tooth designations and descriptions of restorative materials may be inconsistent both in quality and accuracy (Rothwell et al 1989, Jakush 1989, Griffiths 1991). Inconsistent dental notation in records may require translation to a common format (ante- and post-mortem) before comparisons can be made. Failure to update odontogram adds to the confusion (Rothwell et al 1989). Alexander (1970) in his study on dental charting accuracy, found a total of 435 errors in 146 Navy dental records; 21 percent of the dental charts examined were error free and 7 had as many as 15 errors per record. This shows that even the most complete and thorough forensic evaluation will not lead to an identification if the proper ante-mortem evidence is not available for comparison.
Ante-mortem dental records would be inadequate with refusal by a dentist to cooperate in releasing records, or for a patient who had an extensive dental work done and the dental record may have multiple records stapled together, and determining the most recent treatment may take some time (Jerman 1981). However, even though the dental records are the rightful legal property of the dentist, such records may be subpoenaed by the appropriate legal authorities. It is logical and ethical that the entire patient record should be sealed and addressed to the doctor or dentist in charge of the investigation. Illegibility of dental records (difficult to read and figure out what it meant), contributes to the ante-mortem records problems.

The poor quality of many dental radiographs (underdeveloped, underexposed, overexposed or still wet when stored) may hinder the identification process as there are varying degrees of loss of detail (DeVore 1977, Rothwell et al 1989). Many radiographs (when mounted) also lack designations of orientation for left or right and dating which may complicate interpretation.

5.3 PINK TEETH

In many post-mortem examinations, it is not uncommon for the teeth to have a peculiar pink colour (Gustafson 1966, Harvey 1976). It has been determined through various studies that this is due to the haemosiderin released by the breakdown of haemoglobin in the pulps of such teeth. These breakdown products are then absorbed by the dentinal tubules and hence the pink colour. Pink teeth may result from asphyxia. The causes of asphyxia include slow drowning, choking, strangulation, suffocation or hanging (Furuhata and Yamamoto 1967). Endodontically treated teeth, however, remain white and are thus easily identified under such circumstances.

This phenomenon should not be confused with ante-mortem pink teeth which may indicate internal resorption resulting in the vascular pulp becoming visible through the labial surface, or with some other cases of tooth staining.
5.4 FRAGMENTATIONS OF DENTAL EVIDENCE

High energy disasters such as bombings and airline crashes are often accompanied by massive destruction and fire. The debris can be scattered over a vast area of the locus and the human remains can be commingled with one another. Fragmentation of the jaws and loss of characteristics correspond to the degree of mutilation of the rest of the body. In the Woodbridge air disaster in Canada (Petersen and Kogan 1971), fragmentation of the bodies was considerable (800 separate bags of human remains and 134 jaw specimens). The mandibular specimens represented 55 per cent of the possible total number of mandibles. The recovered fragments of maxillae represented 35 per cent of the total; 79 of the 134 jaw specimens (60%) were identified. Occlusal radiographs were used to produce data from the fragments which then are compared with ante-mortem records.

During the Turkish Airlines DC10 disaster at Orly, there were over 20,000 fragments from 370 bodies (Griffiths 1991). In the P-3 crash (Smith and Palian 1985), of the 10 bodies with dental structures present, none contained intact maxillae or mandibles (Figure 17).

Figure 17  Fragmentation of the maxilla and mandible.  
5.5 IDENTIFICATION AFTER BURNING

Dental structures and dental restorations are known to be resistant to fire (Gustafson 1966). In the Parkman-Webster case, the former was lured into the chemistry laboratory of Dr Webster where he was killed and the body was placed in a furnace. However, a charred fragment of Dr Parkman’s tooth fused to gold prosthesis was found in the furnace. Dr Keep, the dentist who had constructed the prosthesis, demonstrated to the court that it fitted the original plaster model which he had kept (Woolridge 1980).

Changes in teeth and restorations may occur when the protecting soft tissues are totally burnt to ash or when the teeth are directly struck by flame. During a fire, the oral cavity is fairly protected. The cheeks and tongue tend to protect the teeth. The teeth can withstand high temperatures if they are not directly exposed to fire; if heated suddenly and severely they may disintegrate (Gustafson 1966, Harvey 1976). In most fire disasters, the flames spread gradually. Additionally, if the body is dead before the fire reaches it, the oral cavity and teeth have a better chance of remaining intact whereas in a living victim, the lips may be drawn back exposing the anterior teeth. Depending on the intensity and duration of the fire, the crowns of natural anterior teeth may be scorched, ashed, or literally explode at the gum line (Harvey 1976).

Depending on the conditions to which teeth have been subjected, and the length of time, heat produces a remarkable variety of changes. By heating a human tooth, that had been fixed in formalin immediately after extraction, at 100 °C, the tooth crown becomes white and resembles mottled enamel but with no change in tooth form (Furuhata and Yamamoto 1967). Microscopically, the enamel rod arrangement is disturbed, dentine and predentine become clearly separated. At 200 °C, the tooth still maintains its form and turns orange. The root transparency increases. At 300 °C, the crown turns yellowish brown and the root dark brown. Cracks begin to form and the enamel arrangement is destroyed. Dentine structure begins to disintegrate and cracks appear at the dentine enamel junction. At 400 °C, the crown is blackish brown and covered with cracks running in all direction. Long cracks appear along
the tooth axis of the root surface. At 500 °C, the crown and root become greyish white. The apical region is more greyish white. Cracks run in all directions and extend along the tooth axis. The enamel exfoliates at the cemento-enamel junction.

Dental restorative materials may be intact or lost in the event of a fire. In cases of intact restorations, certain materials may complicate the identification process. Mercury vapour, for example, from amalgam fillings may volatilise or spread as droplets in the mouth and may contaminate gold restorations. This may lead to a wrong conclusion on the type of restoration.

In cases where restorative materials are lost, the cavity margins may be differentiated from a cavity caused by caries. The former is usually smooth and regular in outline compared with the latter. Fillings in either the buccal or lingual surface of the tooth tend to be easily lost whilst occlusal fillings and fillings involving two or more surfaces remain intact even after intensive conflagrations (Gustafson 1966).

During the accident between two jumbo jets at Tenerife, Spain in 1977, there were 580 badly burnt bodies to be identified. The process of identification took over four months to complete (Dorion 1990).
6 DENTAL SERVICES IN THE MALAYSIAN ARMED FORCES (MAF)

No study is possible on the battlefield;.....in order to do even a little, one has to know a great deal and to know it well Marshall Foch.

The dental services of the MAF Medical and Dental Corps serve the 3 branches of the MAF. With regard to forensic identification, military personnel have a major advantage over their civilians counterparts in that dental records are prepared for all military personnel when they enter the Service. Subsequent treatment is also included in the records as are the periodic examinations.

6.1 ELIGIBILITY FOR DENTAL TREATMENT

All service personnel and their immediate dependents are entitled to dental treatment at the public expense from the date of enlistment until the date of discharge of these personnel. Service personnel (other than those on loan/seconded personnel from other countries serving in the MAF) include:

a. Recruits
b. Regular members of the MAF
c. Embodied volunteers in the MAF
d. Officers granted Short Service Commissions.

(AFMATI, 1976)

While provision of dental treatment to all entitled individuals and for maintenance of dental fitness of the service personnel is the responsibility of the MAF dental officer, the Commanding Officer/Commander of a Unit has the responsibility to ensure that members of his Unit make themselves available for dental inspection and treatment when required.

There is, however, a provision to treat dental problems of dependents of the service personnel by the MAF. The MAF dentist may also treat civilian patients in emergency cases.
6.2 THE DENTAL RECORD

A dental chart and/or record card which charts or records teeth present or absent and work done does not constitute the patient's dental record completely, as may be assumed by some dentists. Any radiographs, clinical photographs, models and other reports fall within the legally accepted concept of a patient's dental record (Hill 1985).

Essentially, the minimum information routinely needed for every patient in the military context includes the following:

a. Personal history - name, age (date of birth), unit currently attached to, branch of service/corps, rank and date of enlistment
b. Relevant medical history
c. Dental charting - teeth present, filled, decayed, occlusion and any abnormalities noted. Wearing of dentures - the number of teeth it replaces and type of material it is made from
d. Condition of the soft and hard tissues of the oral cavity
e. Details of treatment required
f. Details of treatment that has been carried out
g. Date of completion of treatment, if any

All this highly detailed information should be recorded accurately.

6.2.1 MAF dental form - BAT F3

The MAF dental form is known as BAT F3 (Appendix V). The BAT F3 employs the grid system of tooth designation. The front has the service member personal data as well as an odontogram for initial dental examination as a cadet/recruit on entry to the Service and a second odontogram for subsequent treatment and examination while in service. There is also provision for charting the wearing of denture (with type of material), and space for noting any clinical problems. On the reverse of the form, there are columns and rows for noting the date, type of treatment done and the initials of the dentist who carried out the treatment.

The BAT F3 may be used for:

a. Dento-legal documentation for military dental care provided
b. A means of communication between the dentists that contribute to the patients' care
c. A baseline reference for recording dental defect that existed prior to military service as well as indicate the type of treatment required
d. A record of dental status during his term of service
e. Forensic purposes. It is the most immediate source of ante-mortem data in the event of identifying deceased through dental means
f. Research and evaluation purposes
Thus, the importance and value of an updated dental record in determining the identity of deceased personnel during the process of positive identification, imposes an obligation on every dental officer to ensure that the data recorded is highly accurate. An incomplete record is useless. However, Alexander (1970, 1991) and Hill (1985) have pointed out that the ideal record is not always attained by military dentists. Alexander in 1970 surveyed US Navy dental records and reported that a total of 435 errors were found in 146 US Navy dental records. Only 21 per cent of the dental charts examined were error free and seven contained a total of 87 charting errors, that is as many as 15 errors per record. Smith and Palian (1985) reported that of the 14 victims in the P-3 crash in Hawaii, 13 had ante-mortem dental records and 10 were successfully identified using dental means. Two of the 13 records were incomplete, and were therefore of little help.

6.3 DENTAL EXAMINATION

During the recruitment exercise into the Service, the would-be cadets or recruits have to undergo both medical and dental examination. They must be pronounced medically and dentally fit before they are accepted for military training. During the dental examination, the dental officer examines the oral cavity and then fills in the appropriate column in the medical examination form stating whether he/she is dentally fit or unfit for further training. The BAT F3 is prepared and completed and kept in the individual's BAT F4 (i.e. medical document).

6.4 MAINTENANCE AND STORAGE OF THE BAT F3

A review of the literature illustrates the value of dental records in the identification of service personnel killed during war (Gillespie et al 1985, Hill 1985). It is essential that a separate record is filed, kept up-to-date and stored in a 'safe' place away from areas of service (the American Armed Forces had their central repository at Hawaii). However, in the turmoil of conflict, such an ideal place may have to be compromise.

Currently, the BAT F3 and any dental radiographs are kept together with the personnel medical record documents known as BAT F4 (placed in manila) together in a plastic folder.
The plastic folder is normally kept at one of the following places:

a. At the unit's medical centre
b. At the medical centre that serves the whole camp (i.e. for units that do not have their own medical centre)
c. At the nearest Army hospital that serves the whole camp (i.e. for units that do not have their own medical centre)

In a situation where a service member wishes to have dental treatment, he has to go to the respective medical centre or hospital to get his BAT F3 and later, after having his necessary dental treatment and if completed the same day, their BAT F3 will be returned with him/her to the office from which the forms had been earlier extracted, i.e. to the respective medical centre/hospital. Keeping the BAT F3 together with the medical record may have its advantages but unfortunately the BAT F3 has been found to be missing on a number of occasions and it is not uncommon for a service member to have more than one BAT F3 clipped together. The US military dentists also experience the same problem and find it difficult to determine exactly the person's dental condition when there are a number of continuation charts or several charts in the record following an extensive amount of dental work (Jerman 1981).

However, the AFDC retains all BAT F3 of the personnel:

a. for whom, the course of treatment proposed is not yet completed. After the last treatment appointment, the form will be returned with the respective personnel to the AFMC or the Army Hospital
b. of a unit or parts of the unit on a planned programme for recall for examination and treatment. On completion of the programme, all BAT F3 will either be returned to the respective unit AFMC or Army Hospital whichever is responsible
6.4.1 Posting to a new location/unit

Whenever a service member is being posted or a Unit moves to a new location, the dental centre will be informed by the Unit concerned, so that all BAT F3 of the serviceman or members from the unit still retained in the AFDC, may be returned promptly to the Unit's AFMC for transmission. With this arrangement, the BAT F3 are not sent separately directly to the AFMC or AFDC in the new unit, or to the Unit at its new location (if the Unit moves). In the writer's experience with this type of arrangement, it would normally take about two to three months before the personal and medical documents arrive at the new location. Thus, during the transition period if the service member has to go for dental treatment, he will be issued a new BAT F3 which will be added on to the BAT F3 that he had. To keep track of the movement of the BAT F3, the following procedure is applied:

a. All AFMC or Army Hospital are to maintain a record book in which personnel will sign for receipt and return of BAT F3 handed to/returned by them
b. Personnel treated at AFDC are required to sign for the BAT F3 returned to them after completion of treatment
c. Personnel receiving treatment at private dental surgeries or Government dental clinics must be instructed to bring back the BAT F3 after due entry by the dentist or dental officer. It must be emphasised that the personnel are not to leave their BAT F3 behind
d. All BAT F3 despatched/received between AFMC or Army Hospital and AFDC must be acknowledged in writing

6.4.2 The American military experience

It has been the practice of the US Army that their personnel carry with them their medical and dental records whenever they travel to their next location during their tour of duty (Gillespie et al 1985). Following the terrorist bombings that killed 239 US military personnel at the American base in Beirut in 1983 (Gillespie et al 1985) and an airline crash killing 256 US servicemen in Newfoundland in 1985 (Dorion 1990), the US Armed Forces recommended that all American duty personnel are required to have a duplicate OPG stored at a central repository in the USA i.e the US Army Central Identification Laboratory in Hawaii (CILHI). In the Beirut incident, the ante-mortem dental and medical records (stored close to the centre of the explosion) were severely damaged or destroyed. In the Newfoundland crash, they were in possession of the personnel on the plane.
6.4.3 The bombing of the US Marine Headquarters, Beirut

In this incident, where a single suicide commando drove his explosive laden truck into the US Marine HQ building, Beirut, Lebanon killing at least 241 individuals, 239 were identified using various methods of identification as shown in Table 5. The investigators were faced with several factors which complicated the identification process. Due to the effects of the blast and the collapse of the building, many of the remains were mutilated, charred or fragmented. The dental and medical records (kept in the same building) were severely damaged or destroyed. Many of the records sustained were water damaged, torn and/or had sand or gravel impregnated into them. Recovery of the remains took several days. The inadequate ante-mortem dental records (including quality and availability) was also a problem. Based on the experience and lessons learned from the incident, Gillespie et al (1985) offered some recommendations for consideration.

a. Do not allow military members to carry or keep original dental or medical record; during deployment of troops to potential trouble spots or during movements to and from assignments

b. Make duplicate dental and medical records for military members who are deployed to potentially hostile environments. This record would include the most recent bitewing radiographs, history and the dental chartings. The duplicate copy would be taken by the member upon deployment for the necessary usage by dental officers

c. Establish a central repository of ante-mortem dental records and radiographs

d. Include identifying marks in the fabrication of removable prosthetic appliances

e. Ensure that a diagnostic OPG or full mouth x-rays are taken and a completed dental record are accomplished and the originals kept at the central repository

f. Identify and formulate mass casualty identification teams (utilisation of minimum number of dental personnel necessary to accomplish the task (identifying the remains) and work no longer than 12 hour days to minimise error and increases efficiency
Table 5  Summary of the identifications and the methods of Identification in the Beirut bombings Incident.

<table>
<thead>
<tr>
<th>Identification Method</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Servicemen</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td>French soldier</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lebanese national</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Dental and fingerprints</td>
<td>131</td>
<td>(54.8%)</td>
</tr>
<tr>
<td>Dental only</td>
<td>68</td>
<td>(28.5%)</td>
</tr>
<tr>
<td>Fingerprint only</td>
<td>28</td>
<td>(11.7%)</td>
</tr>
<tr>
<td>Medical only</td>
<td>6</td>
<td>(2.5%)</td>
</tr>
<tr>
<td>Visual only</td>
<td>3</td>
<td>(1.3%)</td>
</tr>
<tr>
<td>Dental and medical</td>
<td>1</td>
<td>(0.4%)</td>
</tr>
<tr>
<td>Medical and fingerprint</td>
<td>1</td>
<td>(0.4%)</td>
</tr>
<tr>
<td>Visual and fingerprint</td>
<td>1</td>
<td>(0.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>(0.8%)</td>
</tr>
</tbody>
</table>

6.5 DENTAL RADIOGRAPHS

Radiological evaluation of teeth is valuable for positive examination and comparison and is particularly applicable in complicated identification cases (Whittaker 1981, Stimson 1982). In the writer's experience during examination of recruits and cadets, some of them have sound teeth and have no dental caries at all. In these cases, radiographs will play an important role in identifying the anatomy of the teeth, air sinuses and bones since there is no dental restoration to compare with.

The maintenance of dental radiographs i.e the bitewings, peri-apical radiographs and panoramic radiographs (OPG) is a matter of concern with the present system. OPG is a good screening tool since it gives an overall survey of the teeth and jaws. However, the present dental document does not has the proper accessory for the OPG to be placed. Any radiograph taken is normally placed into a small plastic envelope (except OPG) and kept in one of the following ways:

a. The envelope is stapled to the BAT F3 and kept at the respective medical centre/hospital with the medical document
b. The envelope is kept in the dental centre itself separated from the BAT F3
c. The OPG is kept at the Army Hospital or at Mindef AFDC
In situations b and c, from the writer’s experience, whenever the service member is transferred to another unit, more often than not, his dental x-rays is left behind. It is therefore possible that an important ante-mortem record (dental x-rays) is left behind, if not lost.

6.6 DENTAL PROSTHESES IDENTIFICATION

There is a considerable number of service personnel who wear partial dentures and a few are wearing full dentures. In an edentulous individual, it is more difficult to use the oral cavity as a means of identification. The examiner can no longer look for restorations, size, shape and number of teeth and other dental characteristics. If the dentures (full or partial) are labelled/marked, they may help to establish the owner’s identity.

The wearing of dentures, the number of teeth replaced, and the type of material used is normally noted in the BAT F3. Even though the number of edentulous service personnel is few in number when compared with those wearing partial dentures, the dentures (full and partial) are not marked to help in identification purposes. The information about any dentures written on the BAT F3 is insufficient as normally the information noted would be the teeth it replaces, the material used and shade of the artificial tooth. Any repair done to the denture is not normally recorded or if it is recorded, the dentist would write on the BAT F3 as ‘repair of denture - done’. It is also not uncommon for the dental technician not to duplicate the study model for making dental prostheses either for partial or full dentures. This study model, unfortunately, is also the working model and is therefore sheared into pieces and thrown away after the denture is ready. Except for orthodontic purposes, all cast models are discarded and not available for forensic use.

Edentate and partially edentate persons constitute a sizeable portion of the population. In the adult dental health survey in Malaysia during the 1974-1975 period, a total of 4908 adults (54.7%) were in need of dentures but only 2134 adults (43.4%) of those needing them wore dentures (Majid 1984). Of those wearing, 27.2 per cent had full dentures, 68.1 per cent had partial dentures, 4.7 per cent wore a combination of full and partial dentures. Of the 2774 adults needing but not wearing dentures, 83.3 per cent needed partial dentures, 9.5 per cent need full dentures and 6.6 per cent needed a combination of full and partial dentures.
In a study on patients' preference for exodontia versus tooth preservation in Malaysia, 41 per cent of the patients interviewed preferred exodontia (Razak et al 1990). On utilisation of dental care, Jaafer and Razak (1988) studied 500 dental records of adults attending the University of Malaya's dental centre and noted that 61 per cent had requested extractions and 57 per cent requested dentures.

6.6.1 Denture marking

The importance of denture marking was summed up by Haines (1973) on the basis of 18 literature references and evaluation of 8 air disasters involving 380 victims, 50 victims (13.2%) and 47 victims (12.4%) had complete and partial dentures respectively. Only 7 out of 97 dentures were marked with the victims name.

The reasons for denture marking (Dorion 1972a,b) are:

a. Identification marks can identify the owner when natural teeth are no longer present
b. In cases of lost and found, the denture can be returned to the owner
c. It serves to identify an unknown denture wearer in cases involving amnesia or senility, loss of memory, psychiatric cases, homicide, suicide or victims of fire, explosion, disaster like floods, earthquake, plane crash or victims of war
d. A rapid, accurate system other than fingerprinting is essential for identification of denture wearers
e. In the laboratory, the dental technicians will find it harder to lose or misplace a denture especially at the de-flasking stage if it is marked/labelled
f. To ensure the correct denture is delivered to the patient (Jerman 1970)
g. To provide a possible means for later identification if the patient is involved in a plane crash, explosion or fire (Jerman 1970)

Krüger-Monsen (1962) proposed some requirements for marking dentures:

a. It must be easy to perform and not costly
b. The method should not influence the strength of the denture
c. The identification must be carried out in a simple manner without having to make a separate lists and numbers
d. The marking must be protected and visible after a long period of wear
e. The identification must not change in fire or humidity

Various authors had suggested the incorporation of the patient's name (Lose 1958, Woodward 1979) while one suggested the patient's social security number (Jerman 1970).
6.6.1.1 Marking methods

Dorion (1972b) lists the following methods of marking denture:

a. **Engraving.** This system involves marking the models so that the denture carries the identification marks upon fabrication. However, this may lead to soft tissue irritation due to 'high spots'. Subsequent grinding may lead to elimination of the marks.

b. **Scribing.** This method involves the marking of the denture after it has been fabricated either with a bur, stone, diamond, knife or any other sharp instrument.

c. **Writing.** It involves the slight dicing of the posterior flange of the denture (non-tissue bearing side), marking the patient's name and service number on the roughened surface and painting a coat of nail polish over the area.

d. **Inclusion.** This involves the replacement of part of the denture material (pink acrylic) with a second material (clear acrylic) and a medium upon which is inscribed the name and service number. The inscribed material becomes part of the denture and not an addition to the denture.

6.6.1.2 Medium used

The following media may be used as denture markers:

a. **Paper, onion skin, nylon, linen or fibre glass** are suggested (Harvey 1966, Carmen 1980, Woodward 1979). The identification marks can be written on any of these media either in pencil, pen, or typewritten.

b. **Metal inserts** from materials such as stainless steel orthodontic band, matrix band material, shim steel material or aluminium (Harvey 1970).

c. Use of **radiopaque materials** (Stellon and Chex gauze) which contain barium sulphate.

6.6.1.3 Position of the medium

It is noted by several authors that in many cases of air disaster where the limbs are completely burnt off, some denture materials survive, especially the posterior part of acrylic dentures and metal-based dentures (Harvey 1966, Gustafson 1966, Haines 1973).

With regard to the possible area the markers to be placed, some authors have recommended that it should be **placed along the posterior border**, anterior to the palatal seal of the maxillary dentures, as this area has been shown to be the last to be destroyed (Harvey 1966, Jerman 1981) and **along the lingual flange posteriorly** under the teeth for the mandibular dentures. If the marker is destroyed, then the denture is likely to be destroyed too.
6.6.1.4 Denture marking technique

Various methods for denture marking have been mentioned by several authors (Woodward 1979, Harvey 1970, Dorion 1972b, Jerman 1981). However, the method for inserting the strip should not be complicated. The procedures are identical to the normal processing procedures to the point of final closure of the flask during the packing process (Woodward 1979).

The steps in the procedure are:

1. Place a strip of tin foil of about 5cm by 2cm onto the model (area is specified as in section 6.6.1.3). Then make a trial pack as usual
2. Open the flask; remove the tin foil strip. The patient's particulars, typed on the medium to be used (about the size of the tin foil), are placed into the area left void when the tin foil is removed
3. Moisten the area with monomer; and place clear acrylic resin over the strip of the medium to fill the void
4. Finally, close the flask and process as usual; then re-cover and finish the processed denture

6.7 CONTINUING EDUCATION

Continuing education within the dental services of the MMDC is scarce. Other than those conducted by the visiting Royal New Zealand Dental Corps dental officers, there is almost no continuing education among the MMDC dental officers. In February 1991, however, a field dental training exercise, cum dental discussion, was initiated and conducted. The exercise became known as the 'Ex Taring' series.

The purpose of continuing education is to:

a. Act as a refresher course
b. Create interest and awareness among participants
c. Keep abreast with advances in dental research and techniques
d. Acquire a 'hands-on' experience and familiarisation on the subject
e. Maintaining professional status, as learning is progressive
The subject of forensic dentistry should also be taught in dental school with the following aims:

a. To produce a dental graduate with that level of skill and competence in forensic dentistry expected of a general practitioner
b. Produce a dental graduate with a level of skill and competence in forensic dentistry to be an effective participant with local, state or federal authorities in civil or criminal matters requiring dental expertise
c. Produce a dental graduate who appreciates his responsibility to assist the medico-legal community
d. Produce a dental graduate who appreciates his responsibility to participate in continuing education and research in the field of forensic dentistry

Continuing education among service members can be difficult but information on the importance of having complete and updated dental data can be distributed to various levels within the MAF. Talks/lectures on 'forensic identification through dental characteristics' could be introduced at the various Army courses which are held:

a. Officers' courses
   i. Cadets - to be held in conjunction with dental examination and charting
   ii. Young officers' course
   iii. Medical and Dental Officers' orientation course

b. Other ranks courses
   i. Medical (nursing) and dental courses for the other ranks in the MMDC
   ii. Senior cadres courses (for MMDC personnel)
   iii. During recruits' six months training - to be held in conjunction with dental examination and charting

The time is appropriate for formal recognition of forensic dentistry in the military. An introductory course on forensic dentistry will not only enhance awareness but at least promote the need for having regular dental checkups among the service personnel once they understand the role of dentistry in identification and the reality of soldiering. This will generate much interest in them once they appreciate the scope of forensic dentistry in particular and their response to any dental activities in the future will, hopefully, be encouraging. This should also augur well for the image of the Dental Services in particular and the MDC in general.
There is also a need for formal training in forensic dentistry among general practitioners in Malaysia. The principles of identification by dental comparison are relatively simple and straightforward and within the clinical skills of any qualified dental practitioner. However, the gruesome conditions of the accident or disaster itself, compared to the ideal and normal conditions of the dental clinic, and the nature of the material to be worked upon (which is frequently very unpleasant and emotionally distressing) may temporarily impair the dental practitioner's judgment.

Dr Norman Sperber, a forensic dentist from San Diego relates that he periodically receives calls from dentists expressing interest in the field and invites them along when an identification case comes up. But after one look at a body with "a head like a pancake", that has been flattened by a 20-wheel trailer rig, Dr Sperber said he's not surprised when he doesn't hear from them again (Jakush 1989).

The dental forensic training may help prepare participants to cope with the situations psychologically with the macabre situations often presented, and delayed stress can be a part of the mass disaster situation that can affect some participants; even experienced forensic dentists are known to experience delayed stress (Jakush 1989). Some of the signs of delayed stress e.g. flashbacks, dreams, dysphoria, mild insomnia, anxiety, fear and avoidant feelings, may not show for weeks or months. The staff need to understand that it's normal to experience some of these things and they should know how to react. It is suggested clergymen, psychologists and psychiatrists can play a role in supporting personnel with stress or psychological problems.
Activities which may help the staff involved in identification process:

a. In and out briefings on mental health
b. Good training and problem exposure in advance
c. Good working areas
d. Reasonable working hours
e. Rotation of staff when possible
f. Don’t identify with remains
g. Observe the staff carefully each day
h. Encourage friendship, support and teamwork
i. Know your people and what’s normal for them
j. Good work clothes and prompt laundry support
k. Unwind together at the end of the day
l. Have adequate sleep and rest
m. Encourage humour
n. Praise the staff and reward excellence
o. Limit criticism
p. Recognise the humanitarian actions being accomplished
q. Care for each other

6.8 FORENSIC DENTISTRY SECTION/DENTAL IDENTIFICATION TEAM

At the present time, there are no personnel in the MAF dental services who are adequately trained in the field of forensic dental identification. The Army may be requested to provide dental assistance with unidentified bodies as a result of a local accident involving a military truck or a bus full of soldiers.

The use of untrained personnel, understaffing or overstaffing can lead to disastrous results and dental discrepancies due to misinterpretation of the dental nomenclature (Dorion 1990), as in the Dallas-Ft Worth August 2, 1985 air crash where the dental charting was done by pathologists before activation of the dental team. The results were erroneous and there were also incomplete charts. Staffing of the dental team should depend on the number of victims and the type of the disaster (Dorion 1990).

As pointed out by Keiser-Nielsen (1980), the identification procedures are mainly:

a. Collection and recording of dental post-mortem data of unknown bodies
b. Collection and recording of dental ante-mortem data of persons reported missing
c. Comparison of the ante-mortem and post-mortem dental data, and
d. Making a report on the outcome of the dental characteristics comparison
The forensic dentistry section should be an integral part of the organisation of the identification centre, staffed by personnel who are highly trained in all the procedures for forensic dental identification. The forensic dentistry section should be divided into three subsections (the ante-mortem dental records section, post-mortem dental examination and dental radiology section, and comparison section) and should be headed by a team chief responsible to the identification chief for the activities carried out by the dental section. The role of the chief of the forensic dentistry section is that of manager, facilitator, coordinator, and spokesperson for the section (Morlang 1986).

The final success of the identification procedures depends, not only on highly trained personnel, but on good teamwork and a strong devotion to the task.

6.8.1 Ante-mortem dental records section

The task of this section is to determine who was involved in the event, locate and procure ante-mortem dental records and dental radiographs, arrange for the delivery of these materials and undertake the process of developing a composite ante-mortem record for each victim from the evidence supplied. The quality, quantity and the variety of dental record documentation of this ante-mortem dental evidence presents the major obstacles to this section. It is necessary to reduce all ante-mortem dental evidence to a single ante-mortem record form by using the FDI format form A or the INTERPOL form ‘I’. The composite ante-mortem dental record may then easily compared to the post-mortem dental record of similar format. At least two members of the section should review each composite ante-mortem dental record as a quality control mechanism. The completed ante-mortem dental composite form should also be quality checked against available ante-mortem dental radiographs.
6.8.2 Post-mortem dental examination and dental radiology section

This section is the actual part of the dental section that is within the forensic processing line. A medical photographer should be available to provide photographic support during the post-mortem examinations. The use of dental radiology in forensic dentistry is a necessity as dental radiographs provide objective evidence that may be presented in court. Jaw resection may need to be carried out for a better radiographic outcome. A full mouth post-mortem dental radiographic series should be done utilising a portable dental x-ray unit. The use of an automatic dental x-ray film processor with a daylight loading hood is recommended as this avoids the requirement for a darkroom.

Following a full mouth post-mortem dental radiographic series, dental examination is carried out. Two dentists, or a dentist and a trained auxiliary, shall chart all dental evidence on a post-mortem dental record such as the FDI format form B or the INTERPOL form J. The charting methods should be consistent with that used by the ante-mortem section. The findings to be recorded during the post-mortem dental examination are dental restorations, missing teeth, prosthetic appliances, and unique tooth anatomy. The findings should be confirmed with radiological findings.

6.8.3 Comparison section

All completed post-mortem and ante-mortem dental records are forwarded to the comparison section. The task of this section is, therefore, to compare all post-mortem examination and radiographic findings with the completed composite ante-mortem dental records and radiographs. This section should also keep abreast of the findings of all other forensic sections within the identification centre and apply their findings in the dental comparison process. Dental comparisons can be accomplished with the assistance of a computer or can be managed in a manual fashion, or by a combination of both techniques. The number of personnel in this section would depend on the type of disaster and the number of victims involved and whether a computer is utilised to carry out the comparison. If a computer is to be utilised in the comparison process, the number of personnel can be reduced.
When utilising the computer, it is necessary to create ante-mortem and post-mortem record files within the computer memory. The computer products provide a list of ante-mortem and post-mortem records for comparison based upon probability. However, the need for computer use in a disaster situation is determined by; size of the disaster; number of specimens; stage of decomposition of the specimen; local conditions; and accessibility to hardware and software (Dorion 1990).

Staffing of the dental team is difficult to determine. For example in San Diego, 1987 a PSA jet and a Cessna collided in mid-air, there were one hundred and forty-four deaths. Twenty-five bodies were processed per day by three teams of two dentists. It took four days to identify one hundred victims (92%) by dental means (Dorion 1990).

In planning a forensic dental section, it is helpful to first define the concept of operation leading to development of individual annexes regarding personnel, equipment, supplies and facilities which can be subdivided based on the proposed size of the operation. The plan might include an annex for personnel (Table 6), equipment, supplies and facilities for dealing with up to 50 fatalities, 50 to 150 fatalities, 150 to 300 fatalities and 300 or more fatalities (Morlang 1986). Thus, the size and composition of the forensic dentistry section is determined by the concept of operation and the anticipated magnitude of the event.

For the dental services of the MAF, due to limited trained manpower, the concept of operation would be to have trained dentists (preferably two) and auxiliaries (chairside assistants, hygienists and dental technicians) to staff the key positions in a dental forensic unit. The two trained forensic dentists, whilst staffing the key positions, would also practice general dentistry to serve service personnel. Meanwhile other dentists and dental auxiliaries in the MAF should be trained in the forensic dentistry identification field. These core of personnel can then be augmented to address the size of a particular disaster as suggested by Morlang.
Table 6  Summary of the staffing of the forensic dentistry section in disaster situation.
Source: Morlang (1986)

<table>
<thead>
<tr>
<th>STAFF</th>
<th>0-50</th>
<th>50-150</th>
<th>150-300</th>
<th>300+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief (Forensic dentist)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Deputy (Forensic Dentist)</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Oral surgeons</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>* General dentists</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Dental x-ray technicians</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
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<tr>
<td>Dental assistants</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Computer operators</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Office manager</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

* The general dentist refers to the dental practitioner who had training in forensic dental identification.
7 RECOMMENDATIONS

The foremost priority for all of us is medical readiness. Unless we ensure the adequate care of our wounded in wartime, we cannot call ourselves medical or military professionals..... History has shown that where military medicine has succeeded, it has done so only by mobilising its resources well in advance of war and where it has failed,...It has been because it did not recognise the coming needs.

General VCE Koop

Based on the information presented in this thesis, some recommendations for the dental services of the Malaysian Armed Forces are made.

7.1 EXAMINATION AND CHARTING

On entry into the Service, the examining dental officer has to prepare and complete the BAT F3 of recruits/cadets. To ensure that all trained soldiers have an up to date dental records, some proposals are made:

a. All recording and charting should be done in duplicate.
b. During the full dental examination and charting into BAT F3, panoramic x-rays (OPG) or at least full mouth bite-wings radiographs should be taken
c. On reporting to their new units after the six months military training, the freshly trained soldiers and officers should report to the nearest dental centre for re-examination and re-charting if necessary for dental charting update and confirming their dental status
d. Every serviceman should be required to have a regular dental examination annually to update their dental status
e. For units with no access to the Armed Forces Dental Centre (AFDC), their unit member should report to the nearest public dental clinic for updating their dental records annually
f. On termination from the Service, the out-going serviceman should have his dental records updated and full mouth radiographs taken
7.2 MODIFICATION TO THE PRESENT BAT F3

The BAT F3 is intended to be used within the MAF for soldiers (not for families/dependents of soldiers) and available singly in card form, and is kept together with the medical document after dental treatment has been carried out. Due to the nature of service life and the mobility of service personnel, there is a great possibility of losing the dental card. Some proposals are made to ensure that dental records are appropriately managed.

a. The proposed BAT F3 should be printed in 2 no carbon required (NCR) paper (i.e. 1 original and 1 copy) so that when filled in the first time it is duplicated as such. Alternatively, a carbon paper should be used in all recordings if the BAT F3 is not printed in 2 NCR paper. The front of the proposed BAT F3 is shown in Appendix VI.

b. A manila folder should be designed solely for dental documents where the BAT F3 and all dental x-rays can be kept. The front of the manila folder should carry the name and service number and have the month of the year printed as it can be use to indicate the month for the annual dental checkup for those personnel who had completed their treatment (Appendix VII). A column for relevant medical history and a key for all the symbols and abbreviations used should be printed on the proposed manila folder.

c. A separate dental record for the dependents of the service personnel should be designed and included in the servicemen’s dental document.

7.3 MAINTENANCE AND STORAGE OF THE DENTAL RECORDS

The maintenance and storage of the BAT F3 at the respective Armed Forces Medical Centres/Army Hospital together with personnel’s medical documents has its advantages and disadvantages. For easy access to the service personnel’s dental documents by the dental services, proposals are suggested for maintenance and storage of the dental manila folder:

a. All dental manila folders of personnel should be kept at the AFDC serving the respective camp/unit or the unit’s AFMC if the unit has no access to an AFDC.

b. Whenever a service member is posted to a new unit, he should report to the AFDC. His original dental documents would be given to him after he has signed a handing-over voucher. The AFDC, however, should keep the duplicate of the dental records. The service member then should hand over his dental records to the AFDC serving his new unit or to his unit’s AFMC for units with no access to the AFDC. The ‘new’ AFDC should then notify the AFDC from where the personnel had earlier extracted his dental documents.

c. A central repository should be set up where all the records are kept; for in-service personnel, retired personnel (and their families if possible). This central repository could be located together with other personal documents currently kept by the Record Section of the MAF.
7.4 DENTAL RADIOGRAPHS

Radiographs tend to substantiate the post-mortem findings. Currently the taking of radiograph is not compulsory during initial dental examination on entry to the Service. During routine dental treatment, a dental radiograph is seldom labelled, dated and mounted. It is therefore proposed that:

a. Either OPGs or full mouth bitewings should be taken at the initial dental examination, whichever is possible

b. All the dental radiographs (intra- and extra-oral i.e bite-wings, peri-apical, occlusal and OPGs of service personnel and dependents) should be labelled, dated, mounted and placed in a plastic folder/envelope for radiographs and secured in the manila folder together with the BAT F3

7.5 DENTAL PROSTHESES MARKING

It has been noted by several authors that in many cases of air disaster where the limbs are completely burnt off, some denture materials survive, especially the posterior part of acrylic dentures and metal-based dentures (Harvey 1966, Gustafson 1966, Haines 1973). Thus, marked dental prostheses (full and partial dentures, mouthguards and removal orthodontic appliances) would lead to rapid identification in the event of accidents and disaster. For the dental prostheses, it is proposed that: all markings for dentures be typewritten on a piece of onion skin paper and included along the posterior border anterior to the palatal seal for maxillary dentures and along the posterior part of the lingual flange below the teeth for the mandibular dentures.

To avoid infringement into ethical problems as to the essential privacy and liberty of the individual, it is proposed: that for service personnel, their initials and service number be included for marking; while for the families and dependents of the service personnel, their initials and identity card number are included.

Since onion skin paper (the paper that separates the pieces of the base plate/ modelling wax) is readily available in dental laboratories, its use is recommended.
7.6 CONTINUING EDUCATION

Since the military community has to be made aware of the importance of dentistry in forensic identification, it is recommended that dental subjects in general and forensic dentistry be taught to the military personnel at the various levels as discussed in section 6.7.

Instruction in forensic dentistry could also be incorporated into the existing dental school especially (University of Malaya) in a multidisciplinary fashion. The undergraduates should be exposed to instruction in the techniques of identification of human remains based on dental evidence i.e. skills required to perform this function within the setting of a mass disaster resulting in multiple visually unrecognisable bodies. The course should also familiarise the student with skills necessary to recognise, gather, preserve, analyse and document evidence associated with bite pattern injury. The student should also be familiar with techniques of presentation of forensic dental information in a court of law and the interrelationship of dental science with the medico-legal system.

7.7 FORENSIC DENTISTRY SECTION/TEAM

An organised uniformed service such as the MAF, especially the Medical and Dental Corps, must not only anticipate mass disaster but must be able to react immediately by supplying **trained personnel** in forensic procedures to carry out routine identification procedures efficiently. As members of the Service are itinerant and disaster could happen at a location distant from military installations, it is recommended that:

a. All military dental officers and dental auxiliaries undergo training in forensic dental identification. This will ensure availability of trained personnel and quick response to such an emergency call

b. The setting up of a forensic dentistry unit comprised of two forensic dentists, and fully equipped with a complete set of the dental identification kit (appendix III)
Prolonged contact with a large number of corpses can lead to psychological problems for the participating identification personnel, especially those with little or no experience. Since stress and psychological trauma can be anticipated, all personnel with stress or psychological problems should be referred to psychologists, psychiatrists and clergymen for support.

7.8 COMPUTERISATION OF DENTAL RECORD / CENTRAL REPOSITORY

The computerisation can lead to easier retrieval and transmission of dental records. Filing of dental records through computer should be implemented in the future in accordance with the military computerisation of all its departments. As such, computerisation of all AFDC is therefore ideal. This would have an added advantage as dental records can be easily retrieved and transmitted (provided there is on-line facility / modem) without the problems of getting lost or arriving late during postings of personnel. Most important of all, computers facilitate the positive identification of the living and the dead, and in dental research as the dental data will be easily obtainable. However, as this would involve a lot of finance, it is suggested that the MINDEF AFDC should, at least, be computerised. A central repository where all dental records of in-service and ex-serviceman are kept is recommended. The records could possibly be placed together with the personal documents of the service personnel at the Record and Pension Section of the Ministry of Defence.
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Appendix I  Dental identification Form B. FDI format of the dental status of human remains (front and reverse)
Source: Courtesy of Dr Griffiths (1991)

<table>
<thead>
<tr>
<th>BONE</th>
<th>OCCUPATION</th>
<th>ANTHROPOTOMIC RECORDS OBTAINED FROM</th>
<th>RADIOGRAPHS REQUIRED</th>
<th>POSSIBLE ID</th>
<th>NOTES</th>
<th>CONDITIONS OF REMAINS</th>
<th>SIGNATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEFT MAXILLARY

| ID | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

RIGHT MAXILLARY

| ID | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

LEFT MANDIBULAR

| ID | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

RIGHT MANDIBULAR

| ID | 60 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

FDI FORMAT
### Victim Identification Form Part J

(Approved by the International Criminal Police Organization - Interpol)

#### Dead Body - Dental Findings

<table>
<thead>
<tr>
<th>Male/Female</th>
<th>REF. No.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Site of recovery</th>
<th>Recovery No.</th>
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</thead>
<tbody>
<tr>
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<td></td>
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<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

#### DENTAL EXAMINATION

- Requested on: [ ]
- Performed on: [ ]

#### MATERIAL

- Jaws present: [ ]
- Upper [ ]
- Lower [ ]
- Removed [ ]
- Yes [ ]
- No [ ]

- Fragments of teeth: [ ]
- Single teeth: [ ]
- Removed: [ ]
- Yes [ ]
- No [ ]

- Other: [ ]
  - Removed: [ ]
  - Yes [ ]
  - No [ ]

#### Supplementary Details

- Specific description of crowns, bridges and dentures
- Further findings (Deciduous, attrition, anomalies, staining, calculus, periodontitis, etc.)
- Radiographic examination of
- Supplementary examination
- Age evaluation (Method)

#### Stamp

- Place and date
- Signature
### Appendix III  
Dental Identification Form A, FDI format of the dental status of missing person (front and reverse)

Source: Courtesy of Dr Griffiths (1991)

<table>
<thead>
<tr>
<th>BODY NO.</th>
<th>OCCLUSION</th>
<th>PROSTHESSES</th>
<th>HABITS</th>
<th>SPECIAL TREATMENT</th>
<th>RADIOGRAPHS RECEIVED</th>
<th>OTHER REFERENCE MATERIAL</th>
<th>NOTES</th>
<th>PREPARED BY</th>
</tr>
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</table>

#### LEFT MAXILLARY

<table>
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<tr>
<th>11</th>
<th>12</th>
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#### RIGHT MAXILLARY

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#### LEFT MANDIBULAR

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<th>64</th>
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#### RIGHT MANDIBULAR

<table>
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<tr>
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<th>78</th>
<th>79</th>
<th>80</th>
<th>81</th>
<th>82</th>
</tr>
</thead>
</table>
### Victim Identification Form

(Approved by the International Criminal Police Organisation - Interpol)

#### Part 1: Missing Person - Dental Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Born</th>
<th>Year</th>
<th>Month</th>
<th>Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</table>

#### CIRCUMSTANCES OF THE DISAPPEARANCE

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
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</tbody>
</table>

#### Dental Information

- Obtained from family members and/or others

#### Dental Data Provided By

<table>
<thead>
<tr>
<th>Dental/Institution</th>
<th>Records</th>
<th>X-rays</th>
<th>Models</th>
<th>Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Tel. No.</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Dental/Institution</th>
<th>Records</th>
<th>X-rays</th>
<th>Models</th>
<th>Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Tel. No.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Filed with
- Attached report to
- Returned to practitioner

#### Stamp

- Place and date

#### Signature
### Appendix V
The MAF Dental History Card - BAT F3

**Source:** AFMATI (1976)

#### DENTAL HISTORY CARD

<table>
<thead>
<tr>
<th>Personal/Army No.</th>
<th>Rank*</th>
<th>Surname and Initials</th>
<th>Regt./Corps</th>
<th>Unit*</th>
<th>Date of Birth</th>
<th>Date of Enlistment</th>
<th>Period of Engagement</th>
</tr>
</thead>
</table>

#### PART 1
**BUCCAL DENTAL CONDITION ON ENLISTMENT**

**RIGHT**

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

**LEFT**

**BUCCAL**

**BUCCAL**

Existing Dentures are under
(If none strike through Grid)

Satisfactory/Unsatisfactory.

Material

Clinical Remarks

Date

No.

Army Dental Centre

Signature of Examining D.O.

#### PART 2
**PARTICULARS OF DENTAL TREATMENT SUBSEQUENT TO ENLISTMENT**

**BUCCAL**

**RIGHT**

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

**BUCCAL**

**BUCCAL**

<table>
<thead>
<tr>
<th>Dental Centre No. and Location</th>
<th>Ref. No.</th>
<th>Date</th>
<th>Treatment</th>
<th>Initials of D.O.</th>
<th>Dental Centre No. and Location</th>
<th>Ref. No.</th>
<th>Date</th>
<th>Treatment</th>
<th>Initials of D.O.</th>
</tr>
</thead>
</table>

...
Appendix VI  The Proposed BAT F3 (Dental Condition on Enlistment)

MEDICAL-IN-CONFIDENCE

BAT F3 (Amended 1991)

DENTAL CONDITION ON ENLISTMENT

<table>
<thead>
<tr>
<th>Service No</th>
<th>Rank</th>
<th>Name</th>
<th>Regt/Corp</th>
<th>Unit/Ship</th>
<th>Date of Birth</th>
<th>Date of enlistment</th>
<th>Period of * engagement</th>
</tr>
</thead>
<tbody>
<tr>
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<td>17</td>
<td>16</td>
<td>15</td>
<td>14</td>
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* To be entered in pencil

Periodontal condition: Localised/Generalised Moderate; Severe. Pocket: Present/Absent
Calculus: Localised/Generalised Slight/Moderate/Heavy. Gingival condition: Normal/Inflamed
Indicate natural dentition replaced: ____________________
Occlusion (Angle's Classification): Class I/II/III

Soft tissue examination:

Clinical Remarks:

Date of examination

Armed Forces Dental Centre

Signature of Dental Officer

Name & Rank of Dental Officer

MEDICAL-IN-CONFIDENCE
## Appendix VII  The Proposed BAT F3 Dental Treatment Subsequent to Enlistment

**MEDICAL-IN-CONFIDENCE**  
**BAT F3 (Amended 1991)**

**DENTAL TREATMENT SUBSEQUENT TO ENLISTMENT**

To be done in Duplicate  
Folio No

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<th>Rank*</th>
<th>Name</th>
<th>Regi/Corps</th>
<th>Unit/Ship</th>
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**MEDICAL-IN-CONFIDENCE**
Appendix VII Front of the Proposed Manila Folder for Personal Dental Record

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<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
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MEDICAL - IN - CONFIDENCE

Relevant Medical History

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<th>Rank (pencil) and Name</th>
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PERSONAL DENTAL RECORD

MINISTRY OF DEFENCE

MEDICAL - IN - CONFIDENCE
Inner Side of the Manila Folder

MEDICAL - IN - CONFIDENCE

Medical History

..... Blood dyscrasias           ..... Heart diseases            ..... Others (please specify)
..... Diabetes                 ..... On medication / Drugs          
..... Epilepsy                  ..... Jaundice                      
..... Hepatitis                ..... Rheumatic fever                  
..... Hypertension             ..... Tuberculosis                    

Radiographs taken

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<tr>
<th>Date</th>
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<th>Periapical (yellow)</th>
<th>Orthopantomograph (OPG) (red)</th>
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Symbols used in dental charting:

- Extraction is indicated
- Extraction done
- Tooth missing
- Root present
- Cavity/caries present
- Impacted tooth
- Tooth unerupted
- Non-vital tooth
- Root canal treatment done
- Indicated for crown
- Temporary crown present
- Permanent crown present; indicate (red) gold or porcelain
- Temporary filling present

Permanent filling present (CR/AR) indicate material used: (colour coded)

- AR DO. Amalgam Restoration (disto-occlusal) present (black)
- AR MO. Amalgam Restoration (mesio-occlusal) present (black)
- AR MOD. Amalgam Restoration (mesio-occluso-distal) present (black)
- CR. Composite Restoration (green)