COMPUTERISED DENTAL CHARTING OF MALAYSIAN ARMED FORCES PERSONNEL FOR DENTAL PRACTICE MANAGEMENT AND FORENSIC DENTAL IDENTIFICATION

A research report submitted in
partial fulfillment for the degree of Master of Dental Surgery

by

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ABSTRACT

Forensic dental identification has been acknowledged as the single most useful method and the most consistently reliable means for the identification of both living persons and human remains. Since the availability, quality and accuracy of dental records in the Malaysian Armed Forces is currently inadequate, this study has explored the potential role of computers in dentistry with particular emphasis on their application in forensic situations for the Malaysian Armed Forces.

The approach to this problem has involved the design of a software programme to integrate a dental clinical management system and the requirements of the forensic dental identification process within the Malaysian Armed Forces. The role of the software programme will therefore include provision of Departmental Management Records, Dental Clinical Records and Utilities (correspondence, statistical analysis and inventory systems) and a system for forensic dental identification. This former function is designed to be complimentary to the Dental Clinic Management System. The Forensic Dental Identification System is designed to retrieve ante-mortem dental data and effect comparisons with post-mortem dental findings for the purpose of forensic dental identification in both routine cases and mass disaster situations.

The current status of dental clinic management systems and computer assisted forensic dental identification programmes were reviewed. This was followed by the development of relevant computer software which can readily be used for the computerisation of dental records within the Malaysian Armed Forces and for forensic identification when required. Finally, suggestions are made for future computer applications in the Malaysian Armed Forces Dental Services.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person except where due reference has been made in the text.

I give consent to a copy of my thesis, when deposited in the University Library being available for photocopying and loan.

Mohd Ilham Haron

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ABBREVIATIONS

1.	ADA	American Dental Association
2.	AFDC	Armed Forces Dental Centre
3.	AFDS	Armed Forces Dental Services
4.	AIGUI	Advanced Internet Graphical User Interface
5.	ASP	Microsoft ActiveX Server Page
6.	CADVI	Computer Assisted Disaster Victims Identification
7.	CAPMI	Computer Assisted Post-mortem Identification
8.	CILHI	Central Identification Laboratory in Hawaii
9.	DVI	Disaster Victim Identification
10.	FDI	Federation Dentaire Internationale
11.	FISE	Forodent Identification Search Engine
12.	FDI	Federation Dentaire Internationale
13.	Gb	Gigabyte
14.	HTML	Hipertext Markup Language
15.	HTX	Hipertext file
16.	HQ	Headquarters
17.	IAFS	International Association of Forensic Sciences
18.	IBM	International Business Machines
19.	IDC	Internet Database Connector
20.	ISO	International Standard Organisation

21.	INTERPOL	International Criminal Police Organisation
22.	LAN	Local Area Network
23.	MAF	Malaysian Armed Forces
24.	Mb	Megabyte
25.	MS-DOS	Microsoft Disc Operating System
26.	MIA	Missing In Action
27.	NCIC	National Crime Information Centre
28.	ODBC	Open Database Connectivity
29.	OMR	Optical Mark Read
30.	PC	Personal Computer
31.	POI	Point of Incident
32.	PIFA	Platform Independent Functional Application
33.	PRDE	Propriety Relational Database Engine
34.	RDAE	Relational Data Acquisition Engine
35.	RepGen	Report Generator
36.	RDBMS	Rational Database Management System
37.	SFPMD	Standardised Forensic Post-mortem Data
38.	SFAMD	Standardised Forensic Ante-mortem Data
39	SQL	Second Quarter Language
40.	Svc. No	Service Number
41.	USAIDR	United States Army Institute of Dental Research
42.	VBScript	Visual Basic Script

43.	WinNTFA	Windows NT Functional Application
44.	WHO	World Health Organisation
45.	WG-FOS	Working Group - Forensic Odonto-Somatology

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CHAPTER 1

INTRODUCTION

General
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1.1 GENERAL

Forensic odontology has important implications in modern society. It may be defined as the application of dental science for the purpose of the practice of the law and the administration of justice. Keiser-Nielsen in 1980 described forensic dentistry as " .... that branch of dentistry, which in the interests of justice, deals with the professional handling and examination of dental evidence, and with the expert interpretation and documentation of the findings made"(1).

The identification of unknown deceased persons is required for legal, criminal, humanitarian and research purposes and forensic odontology is an important part of this process(2-4). A successful outcome of forensic odontological investigations requires the ability to recognise, gather, preserve, organise, document and present ante-mortem and post-mortem dental information. Examples of this process include the positive identifications of the partially burned remains in the Australian "Pyjama Girl" case(5-7), dental fragments of the murdered and burned body in the Ezequiela Tapia case(8), and the victims of the Mt. Erebus disaster in Antarctica(9).

The value of preparing, updating and retaining comprehensive dental records has been repeatedly shown. The availability and adequacy of ante-mortem dental records particularly in regard to their legibility, sufficiency of relevant information, terminology and charting systems used, however, always contribute to problems encountered during the course of a dental identification[10]. A number of methods have been proposed and used to reduce the delay and failure in providing information to identification teams.

With the advent of the computer, there has been a renewed interest in dental management and particularly in forensic dental identification due to the fact that the time consuming manual methods of dental record maintenance and ante-mortem and post-mortem dental comparison can be reduced. Results from a number of investigations have suggested that accurate ante-mortem and post-mortem dental records can be processed for dental comparison by a computer system in single cases and also in mass disasters. This would provide the forensic odontologist with a list of the best matches of ante-mortem and post-mortem dental records in a short period of time without the costly and time consuming task of traditional manual comparison.

Current computerised dental programmes deal separately with dental charting, recording and practice management, and forensic dental identification. Some programmes may be difficult to access or they may be incompatible with available computer facilities. However, a computerised dental programme should be capable of standardisation with regard to dental charting, storing and back-up for replacement of lost records, capture and display on the screen and transmission between the centralised computer dental records and a remote location. It should also compare the ante-mortem and post-mortem dental records, generate a possible match on a computer screen, and print the odontogram to be included in the final report.

The problems of identifying human remains have been, and continue to be, an issue facing the military services. Armed conflict can produce mass casualties, many of whom when found are badly mutilated, decomposed or fragmented beyond recognition. Since military personnel are peripatetic it is important that their dental records should be readily available. Frequent moves or regular postings, service in remote areas and the disturbances of war are some examples of the factors influencing this highly mobile lifestyle. The potential for loss of dental records within the military services is thus far greater than for the vast majority of civilians.

The purpose of this study was to investigate and explore the possibilities of using a computer programme for the Malaysian Armed Forces which would simplify the filing, storage and rapid retrieval of routine dental records, enable transmission of the data between the archives and remote locations and permit their application in the comparison work for forensic dental identification of individuals, particularly battle casualties and victims of mass disasters.

The methods of computation were made on the OdontID Professional© programme, comprising a dental office management system and the provision for forensic dental comparison. This programme was developed to fulfil the specified requirements of the Malaysian Armed Forces Dental Services as follows: administration (departmental); clinical applications; utilities which include inventory, statistical analysis and correspondence, and forensic dental identification. Additionally, in order to share the dental information within global networks a transmission parameter was established. This international access could be achieved if the proposed software package was available with network facilities. This complex and highly specialised programme required a special understanding of forensic dentistry combined with a solid background in computing and computer applications.

At present, the computation of dental records within the Malaysian Armed Forces is hampered by the paucity of available computer knowledge, particularly in dentistry, but also in forensic dental identification. A lack of computer knowledge is also apparent throughout Malaysia. An increasing need for forensic dental identification requires research into methods that might be used to facilitate future forensic dental identifications in Malaysia.

A recent accident which involved two Royal Malaysian Air Force helicopters in a remote area of Sepadan Island, North of Sabah (East Malaysia), resulted in the deaths of 11 military personnel[11]. As in many military exercises such as this one, the personnel involved were from different units. A centralised computer dental database system such as OdontID Professional© programme would have provided a significant contribution to the rapid collection and transmission of ante-mortem dental records. In addition a computer assisted forensic dental identification programme would also have facilitated the comparison process between the ante-mortem dental records and post-mortem data, resulting in a more efficient forensic dental identification process even in such a remote location.

1.2 PROJECT OBJECTIVES

The main objectives of this project may be summarised as follows:

1. To review the literature of currently available related computer packages for dental practice management systems and forensic dental identification.

2. To investigate an approach to be used in clinical practice management including maintenance of dental records for the Malaysian Armed Forces personnel utilising computerised methods linked with a Computer Assisted Forensic Dental Identification System.

3. To develop a computer system for Clinical Practice Management and Computer Assisted Forensic Dental Identification for the Malaysian Armed Forces.

4. To develop a computer programme which would use current and future technologies to perform single case work as well as cope with large numbers of victims in mass disaster situations.

5. To propose plans for future forensic dental identification procedures within the Malaysian Armed Forces and the civilian population.

1.3 THESIS OVERVIEW

A review of the literature of forensic odontology including the importance of personal identification in modern society, problems concerning the dental identification process, and the contribution of forensic dental identification in personal identification are given in Chapter 2, section 2.1 through to 2.2. This chapter includes a discussion on existing methods and how they were established in order to improve the process of identification (section 2.3 through to 2.6) together with the summary in section 2.7 which introduces the present research.

In Chapter 3, section 3.1, existing computer programmes are reviewed with particular reference to those features which are included for the Dental Office Management System, the Computer Assisted Dental Identification process, and combinations of both systems. An overview of a number of programmes for computerised dental record system are given in subsection 3.1.2. These include:

1. Dr. DO-Little for Windows 95 and NT.
2. ATS™ Dental System.
3. ToothPics™ Patient Management System.
4. DentalMac· Practice Management System.

5. MacSpecialist II Management Accounting Package.
6. Ultima For Dentist.
7. HI-TECH Dental Programme.
8. Dentrix™ Practice Management System.
9. Dentech For Windows 95.

Computer Aid to Dental Identification in Mass Disasters, Computer Assisted Post-mortem Identification (CAPMI), IDENTIC, and Disaster and Victims Identification (DAVID) of the computer assisted dental identification programmes are presented in subsection 3.1.3. Even though available features of these software packages are described, not all of the currently existing software provides all of the desired features. Subsection 3.1.4 deals with the OdontID© programme for dental identification, which is in current use by the Forensic Odontology Unit, University of Adelaide. The features addressed here include programming language and software used, user interface, hardware used in conjunction with this programme and specific features provided by OdontID©.

This is followed by the formulation of necessary criteria for ideal operating procedures to be included in both a computerised dental management system and computer assisted forensic dental identification (section 3.2). Finally, to make the system easy to operate, the formulation of related methods for user friendliness are discussed in section 3.3 followed by a brief discussion of the related methods for database and cross matching programmes which have been used for this system.

Chapter 4, section 4.1 through to 4.4, mainly deals with a description of the computer software developed and hardware used for this research. The written programmes can be used to computerise dental records from existing manual dental data and odontograms, and for forensic dental identification.

Detailed discussion of the computation methods for the database and cross matching programmes (presentation of the graphical output from both systems), the formulation of the method for analysis of this programme and the numerical results are given in Chapter 5, section 5.1 through to 5.4. The new system was analysed and compared with the existing programmes and some predicted results are presented in section 5.5 together with recommendations for application in the Malaysian Armed Forces given in section 5.6.

This is followed by Chapter 6 which provides the conclusions and suggestions for future dental record computation and forensic dental identification. Finally, Chapter 7, section 7.1 through to 7.6, considers dental notation systems, examples of odontograms, initial query entity types, execution of the OdontID© programme, a questionnaire for evaluation of the user interface and results of the programmes tested.

CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

> ***"Show me the manner in which a nation or a community cares for its dead and I will measure with mathematical exactness the tender sympathies of its people, their respect for the laws of the land, and their loyalty to high ideals."***
>
> **Sir William Gladstone**

Forensic Odontology is the application of all branches of dental knowledge for the purpose of practice of the law and the administration of justice[12,13]. The forensic odontologist is an expert witness whose function is to supply the court with reliable scientific evidence to enable them to reach a judgement as to the merit of a scientific issue, in order to preserve human rights[14].

According to Taylor,..."an expert is a person who has extensive skills or knowledge in a particular field which enables the witness to give an opinion about matters relating to the case" [15]. The scope of forensic odontology is broad and challenging, and extends to both civil[16-19] and criminal jurisdictions[20-23]. Cameron and Sims[23] divided forensic odontology into three major fields, as shown in the Table 2.1.

Table 2.1 Classification of the scope of forensic odontology (Cameron and Sims.)
Source: Cameron and Sims (1974)

Civil	Criminal	Research
Malpractice and all aspects which may lead to criminal charges (fraud).	Identification of living or dead persons.	Age estimation of living and dead persons based on examination of evidence in cases (criminal or civil).
Negligence where damages may be sought and may result in criminal investigation.	Investigation and interpretation of bite marks and lip prints.	Academic training and course work for undergraduate and post-graduates[24-26].
Identification of individual remains where death is not due to suspicious circumstances whether in fragments or complete.		
Identification of living persons in cases of amnesia or senility.		
Identification in mass disasters.		
Legal significance of dental traumatology.		

The identification of unknown deceased persons has important implications in modern society. It rests upon legal, humanitarian, criminal, and research principles and includes considerable assessment of the circumstances relating to the incident[2-4]. The need for identification arises in a variety of circumstances, and although it generally relates to situations of unexpected or violent death of individuals, can also be necessary for living persons.

The *legal* aspect is of the utmost importance for initiating the settlement of an estate, payment of insurances and pensions, marriage of a surviving spouse and business interactions which are all dependent upon a valid death certificate. Living persons suffering coma, loss of memory through shock, trauma, old age, senility, and other psychiatric causes) may also need to be positively identified. In some cases people deliberately wish to give false identification, to escape from legal confines and restrictions, or from the desire to reap, prematurely, the benefits of life insurance[3].

Humanitarian considerations allow for the termination of emotional strain resulting from the unknown whereabouts of a family member. This applies to missing persons and cases of military personnel declared as *missing in action* (MIA) during armed conflict. To end the search for a missing individual confers basic human dignity on the dead. When the remains of the dead are returned to the surviving next of kin a proper funeral service in the religious interests of the relatives is made possible[27,28].

In *criminal* cases such as homicide, suicide or death by violence, vital evidence may depend upon accurate identification of the victim and the establishment of the victim's relationship to a suspect. These points are fundamental to police investigations and may provide major clues in an investigation. Positive identification of the victim may assist in determining a pattern of killing as in the cases of Jack the Ripper, Buck Ruxton, David Berkowitz (Son of Sam), Kenneth Bianchi (Hillside Strangler) and Peter Sutcliffe (Yorkshire Ripper). These perpetrators went to great lengths to dispose of the bodies in such a way that identification was not readily apparent[8,29,30]. In military situations, it is important to verify the death of a soldier who may have had access to sensitive information in order to ensure that the information is not compromised.

Research considerations include the investigation of aircraft accidents, where identifying members of the aircrew is an important factor in determining the cause and manner of an accident, which may have been due to either human error or mechanical malfunction. Positive identification of aircraft accident victims enables an assessment to be made against known seating location and crash scene data. This then allows reconstruction of crash mechanics and injury patterns, and can provide important information which may lead to an improvement of the man-machine relationship in order to prevent future accidents[31].

Forensic identification has to consider two aspects, the personal identity and physical characteristics of the person[30]. The personal identity is built up from personal belongings such as clothing with initials, engraved jewellery and personal documents. This method of identification can provide useful clues in a presumptive identification which may lead to subsequent investigations which are able to scientifically confirm the identification. However, it is not considered to be a completely reliable independent method since loose objects can be mislaid or switched between bodies or deliberately "planted" on them.

The physical characteristics of the person are the records or data held in various locations such as fingerprint, medical and dental records. Any of this data is most valuable in identification, and can provide conclusive legal proof of the identity of an individual "beyond reasonable doubt"[32-35].

The individual identification in forensic investigations can be divided into two categories, non-problematic and problematic[35]. The majority of individual identifications are non-problematic, and occur for people who die in the company of family or other acquaintances usually in the home or a place in which the deceased was known. Under these circumstances, the identification is made visually and is based on the testimony of those who knew the deceased in life, with further substantiation by accompanying documents.

An identification becomes problematic when the remains of an unknown person are found, routine recognition methods are not applicable or the results are questionable. For instance, when the body is disfigured, decomposed, incinerated or skeletonised, visual identification becomes unreliable and therefore not appropriate(36,37). For these reasons other means of confirming positive identification are necessary and include fingerprints, tissue typing techniques [DNA (Deoxyribonucleic acid) typing](38), blood group antigens(39,40), and medical and dental examination.

The identification of large numbers of unidentified bodies is an important function of forensic odontology, made necessary by such mass disasters as aircraft accidents, earthquakes and fires(41,42). The identification process is a complex procedure, requiring the close cooperation of large numbers of people from many disciplines, often of different nationalities, language and geographical separation. Any seemingly small piece of information may subsequently prove to be very significant[27,32,9,43,44].

In cases of mass disasters the process of identification is greatly influenced by such variables as the condition of the disaster site, the adequacy of storage and examination facilities for the victims, and the local laws relating to the disposal of bodies. Brown has discussed the procedures and difficulties involved in identifying human remains[10]. Such identifications are painstaking and very labour intensive, and are usually accompanied by pressure from police, coronial officers, family or next of kin, and politicians. The nature of the task is such that those involved will wish to bring the investigation to a successful conclusion as soon as possible.

It is an absolute necessity that forensic identification is thorough, accurate and speedy, especially where the victims are severely mutilated, decomposed or incinerated, in order to minimise the distress suffered by surviving relatives. Identification is also important in order to conclude investigations, to establish proof of innocence or guilt of a person accused of a crime and lastly to issue the death certificate before the body can be disposed. Another important aspect of identification is that it can also help to establish the cause of an accident so that measures to prevent recurrence can be initiated promptly.

The traditional forensic identification method has centred directly on a three phase process:

1. The collection and recording of the ante-mortem records of the suspected missing person.

2. The post-mortem examination and recording of the unknown remains.

3. Comparison of the ante-mortem record of the suspected victim with the record(s) of the post-mortem examination(s) of the actual victim(s).

This process is supported and corroborated by a detailed description of direct visual recognition of personal possessions such as jewellery, clothing and documents. The contribution of each phase in this method of identification will vary for each situation, and therefore every effort must be made to collect all relevant ante-mortem and post-mortem data to identify victims as soon as possible following an incident[45,46].

If an accident occurs in the locality in which the victims lived, or when a small number of victims are involved, the time taken to search the requisite ante-mortem information may be minimal. However, a large number of tragedies in recent years, particularly those involving aircraft, have involved a large number of victims and in most instances occurred at sites some distance from the residential location of these people. In these circumstances, considerable time may pass before the required material can be collected for use in the identification centre[9,47,48].

These difficulties have been documented in the literature from past experiences[28,29]. Even when the names of the victims are known, there is no guarantee that the required ante-mortem records are available or will be automatically produced in the shortest possible time.

There are multiple methods of establishing identity. Teeth and dental material play a major part and have been conclusively proven to be the single most useful method and the most consistently reliable means for the identification of both living persons and human remains[36,38,43,49-52]. This was supported and described by Simpson (1951), when he wrote "... a subject which has in the last few years come to be of first class importance in crime reconstruction, the identification of human remains or an otherwise unidentified body, usually the victim of a crime, by means of dental data"[53].

There have been many reported cases where identification by visual inspection and fingerprints were impossible or not possible especially in mass disaster situations or in circumstances such as incineration, drowning, decomposition of remains, skeletal remains or in cases of extreme mutilation. Dental identification may have been the only means of identification available and the methods used in these cases included the comparison of ante-mortem dental records and post-mortem dentitions[37,50]. Dorion[54] in 1990, compiled and listed the findings of thirteen aircraft accidents and ten major disasters as presented in Tables 2.2 and 2.3.

Teeth and filling materials are an invaluable aid in the identification of human remains because they are resistant to breakdown, individual in characteristics, and it is usually relatively easy to recover or obtain the ante-mortem dental records when they are available. Table 2.4 lists the disasters over a ten year period between 1982-1992 with the number of fatalities involving dental identification by British forensic odontologists[55].

Table 2.2 Findings of thirteen investigators of fatal crashes between 1951 and 1972.
Source: Dorion (1990)

Author	Number of Victims	Dental Method		Dental + Others
		Number	(%)	(%)
Teare 1951	28	3	11	-
Honolulu 1962	27	14	52	-
Haines 1967	72	34	47	8
Keiser-Nielsen 1963	42	10	24	43
Keiser-Nielsen 1963	101	0	0	45
Salley 1963	127	62	49	-
Fisher 1963	81	3	4	16
Blair 1964	23	3	13	43
Stevens & Tarlton 1966	218	21	10	-
Harmeling *et al.* 1966	57	43	75	-
Haines 1972	78	58	74	-
Boone Country 1967	67	19	28	-
Van Wyk 1969	123	6	5	20
Peterson *et al.* 1971	109	53	49	11
Ashley 1972	162	70	43	-
Ashley 1972	64	10	16	-
Waaler 1972	24	6	25	38
Luntz & Luntz 1972	28	25	89	-
Beckmann 1974	148	59	40	43
Total	1573	475	30	12

Table 2.3 Findings of ten major disasters involving airline, steamship and a mass-suicide.
Source: Dorion (1990)

Location	Date	Airline	Total No. of Deaths	Dental (%)	Dental + Other (%)	Dental Personnel	Time (Hour)	Computer
SS Noronic Steamship	Sep 49			20		40	2880	no
Woodbridge, Ontario	Jul 70	Air Canada	109	49		12	384	yes
Miami, USA	Dec 72	Eastern, USA	101			?	60	no
Pago Pago	Jan 74	Pan Am	96	57		13	840	no
Canary Islands	Mac 77	Pan Am KLM	326	48		30	1008	no
San Diego, USA	Sep 78	PSA	144	76	9	30	96	yes
New Orleans	Jul 82	Pan Am	154	60		30	1440	no
Dallas, USA	Aug 85	Delta	130	68	15	7	168	no
Gander	Nov 85	Arrow Air	256	68	5	39	1008	yes
Jonestown, Guyana	Nov 78	Mass Murder	913	25		100	1176	yes
Total			2347	33				

Table 2.4 Disasters over a ten year period 1982-1992 (with number of fatalities) involving British forensic odontologists.
Source: Clark (1992)

Year	Aviation	Marine	Railway	Football Ground	Total
1983	British Airways helicopter Penzance, UK (20)				20
	Gulf Air 737 Abu Dhabi				111
1985	Air India 747 Atlantic off Cork, Eire (329)			Bradford, UK (56)	385
	British Airtours 737 Manchester, UK (55)				55
1986	British Intl Chinook helicopter North Sea, Scotland (45)				45
1987	SA Airways 747 off Mauritius (160)	Townsend Thoresen ferry Zeebrugge (193)	King Cross Station Fire (31)		384
1988	Pan Am 747 Lockerbie Scotland (270)	Piper Alpha oil rig North Sea, Scotland (167)	Clapham Junction collision (35)		472
1989	British Midland 737 Kegworth, UK (44)	'Marchioness' pleasure boat River Thames (51)	Purley collision (5)	Hillsborough Sheffield, UK (95)	195
		Drilling ship Seacreast Gulf of Thailand (91)			91
1992	Thai Airlines A310 Kathmandu (113)				113
	PIA A300 Kathmandu (167)				167
Total	1314	502	71	151	2038

Human teeth can be destroyed and lost relatively rapidly from disease and trauma during life, and yet they are the most protected and remarkably durable part of the human body after death[56-58]. As the reliability of other means of identification decreases, the importance of dental identification increases. Dental hard tissues are resistant to destructive influences over long periods of time and under the most extreme circumstances such as heat, trauma and decomposition which profoundly modify soft tissues and even bone[77-80]. Even after such severe destruction age[24-26,63-68], occupation[69,70], illness[71], gender[72], and race[42,73-76], may be estimated from teeth and skull parameters[77-80]. This was shown by the identification of the partially burned body of Linda Agostini in the "Albury Pyjama Girl" case of October 1934 which was not successfully completed until ten years after her death[5-7,82].

The history of forensic odontology includes examples of how dental evidence has been accepted and recognised in courts of law. In 1849, a dentist, Dr. Nathan Cooley Keep and his assistant, Dr. Lester Noble, produced dental exhibits in court consisting of the remains of a partial denture manufactured by them and used in the recognition of the incinerated body of Dr. George Parkman, who had been stabbed, dismembered and partly burned in a furnace by his friend, Professor Dr. JW Webster[81].

The individuality of the human dentition is based on multiple points of comparison which present in varying combinations such as rotated teeth, diastemas, chipped teeth, missing teeth, discolouration, distinct dental restorations, and appliances[83]. These variations may alter the status of the one hundred and sixty surfaces of a given set of thirty-two adult teeth, each crown comprising five anatomical surfaces.

Computer models have shown that there are more than 2.0×10^9 possible combinations for charting human tooth surfaces[84]. Keiser-Nielsen applied the theory of probability, demonstrating at least 601,008,390 possible combinations in the case of sixteen teeth missing by using a computer method of comparison[85,86].. Sognnaes, *et al.* in 1982[83] (Figure 2.1 and Tables 2.5, 2.6 and 2.7), and Rawson *et al* in 1984[87] used computer analysis in the investigation of bitemarks demonstrating the unique individuality of the dentition and thereby the potential for identification of bitemarks produced by the human dentition.

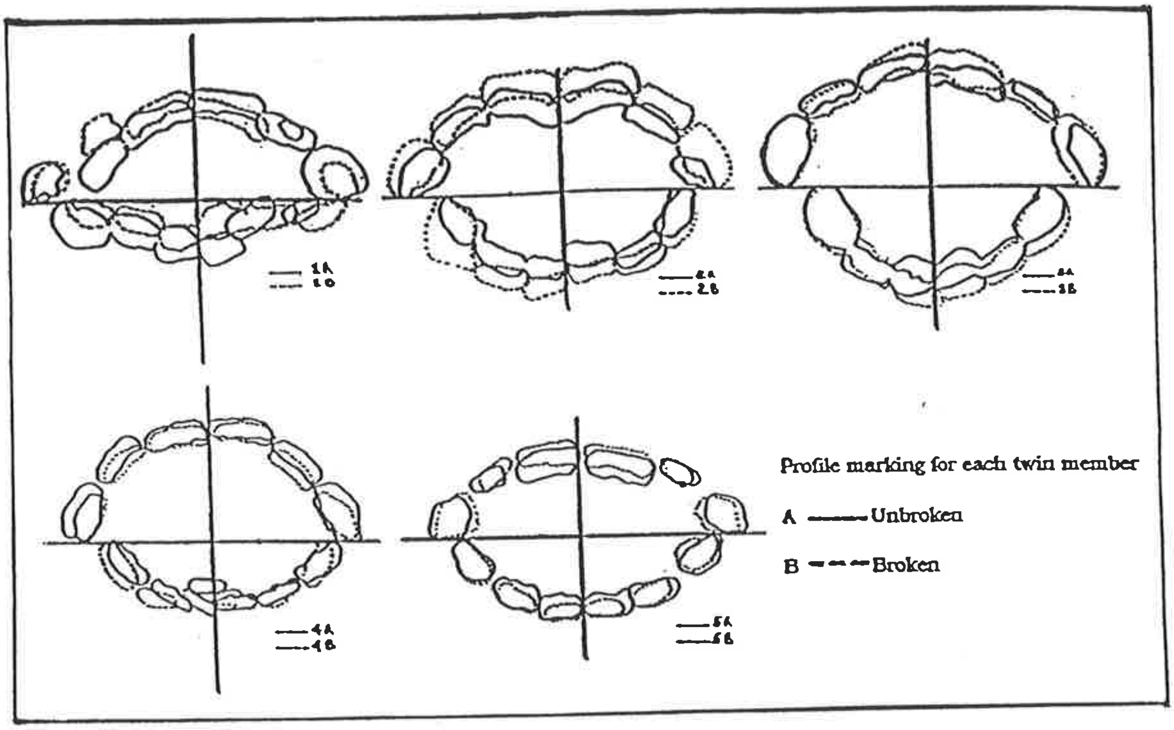

Figure 2.1 Computer printout of bitemark pattern in five pairs of monozygotic twins compared by superimposition.
Source: Sognness, Rawson, Gratt and Nguyen (1982)

Table 2.5 Asymmetries in anterior/posterior alignment of anterior teeth (right over left side in mm).
Source: Sognness, Rawson, Gratt and Nguyen (1982)

Twin Pair No.	Maxillary			Mandibular		
	Canine Tooth	Lateral Incisor	Central Incisor	Central Incisor	Lateral Incisor	Canine Tooth
1A	- 13.0	+ 0.05	+ 4	+ 3.5	0	0
1B	+ 1.0	- 1.0	- 2	- 5	- 1.5	0
2A	- 0.5	+ 0.5	+ 1.5	- 5	- 1	0
2B	0	+ 2.5	+ 1	- 4	+ 1.5	+ 0.5
3A	- 1.0	- 2.5	- 3.2	- 3	- 2	0
3B	0	- 0.2	0	- 3	0	0
4A	0	- 1	+ 2.5	+ 5	- 2.5	0
4B	- 0.5	- 3	+ 3	- 1	- 1	0
5A	0	0	- 1.5	- 2	- 1	0
5B	0	0	0	- 3	0	0

Table 2.6 Angulation of incisal test bite patterns.
Source: Sognnaes, Rawson, Gratt and Nguyen (1982)

Twin Pair No.	Degrees Of Maxillary Incisor Angles: Left Laterals Vs Centrals	L/R Centrals Vs Centrals	Right Laterals Vs Centrals
1A	165	137	167
1B	172	135	174
2A	145	198	130
2B	153	190	146
3A	165	153	1170
3B	185	143	165
4A	148	160	140
4B	153	169	140
5A	175	153	160
5B	155	165	170
Average	162	160	156

Table 2.7 Depth of test bites from anterior dentition, maxillary test bite indentations (mm).
Source: Sognnaes, Rawson, Gratt and Nguyen (1982)

Twin	Maxillary			Mandibular		
Pair No.	Canine Tooth	Lateral Incisor	Central Incisor	Central Incisor	Lateral Incisor	Canine Tooth
1A	4.6	2.4	1.5	2.0	2.1	1.5
1B	2.0	2.2	1.7	1.9	2.8	2.1
2A	1.8	2.1	1.9	1.8	2.5	1.7
2B	1.6	2.0	1.7	1.7	2.5	1.6
3A	1.6	1.6	1.9	1.7	2.4	1.7
3B	1.7	2.2	1.9	1.6	1.8	1.8
4A	1.7	2.3	1.6	2.0	2.0	1.5
4B	1.6	2.5	1.7	1.9	2.4	1.7
5A	1.6	3.1	1.8	2.0	3.1	1.6
5B	2.2	3.3	1.7	1.6	3.1	2.9

The number of identifying features have infinite possibilities and given sufficient data no two sets of teeth are identical[43,45,51,59,81,84-88]. Where sufficient numbers of features have been recorded and are compared to the features in the mouth of a human body, if the features are identical it is sufficient to state that the body is of a specific person "beyond reasonable doubt".

When an accident occurs as a result of criminal activities, such as hijacking, terrorism or extortion plots, it is necessary that an attempt is made to identify all bodies conclusively by fingerprints, dental comparison or DNA. Personal effects and clothing are not always individually designed and may be borrowed, stolen, or switched between people with criminal intent[8,28,64,89]. Deliberate body disfiguration of murder victims has been carried out in an attempt to confuse identification. In the Ruxton case, it was found possible using the remaining dental and skeletal evidence to assess and provide satisfactory proof of the respective ages and identities of the two murdered women[5,8,90].

Another asset of dental identification is that ante-mortem records may be retrieved with relative ease from the attending dentist[26,33-35,49,91]. In the case of an air disaster in Woodbridge, Canada (1971), 79 of the victims (72 %) were positively identified and dental methods proved of paramount importance, 53 bodies (49 %) were identified by dental methods[91]. Although fingerprints had been well preserved because of clenching of the hands, the retrieval of good ante-mortem prints of all victims proved inefficient and precluded rapid identification.

Dental identifications have been of significant value in victim identifications even though they may have been scattered widely as a result of explosions, as in the air disasters that occurred in Stockport[92], Windhoek[30], Dubai[93], Woodbridge[91], in the Moorgate underground disaster[94], the S.S. Noronic disaster[95], as well as the 1980 Mount St. Helens eruption[96]. Haines reported that in the Stockport air disaster[91], two cases of supposed visual identification of remains were proven by dental examination to be in error. Jakusa reported that the remains of US military personnel MIA's from Vietnam and Korea were brought to the United States Army Central Identification Laboratory in Hawaii (CILHI) and most of them were identified through dental records[97].

2.2 PROBLEMS CONCERNING ANTE-MORTEM RECORDS

The fundamental element of the forensic dental identification of unknown human remains is a comparison of ante-mortem and post-mortem dental records. Although each individual incident will bring its own particular requirements, there is one basic need that is common to all cases. The identification team requires every available piece of ante-mortem dental data relating to the known or suspected victims(26,30,31,49,98). This information should be collected and transmitted as soon as possible to the identification centre(9,95).

Difficulties faced by forensic odontologists in the past have been documented in the literature over a number of years, and include the fragmentation of dental evidence and the variable quality and status of ante-mortem dental records(10). Ante-mortem dental records include written records, dental radiographs, dental casts (models) and photographs, and should be collected by an investigative agency which has access to missing persons reports at the local, state, national and international police agencies (INTERPOL) levels. However, the standard of ante-mortem dental records varies, including their availability, quality and accuracy. In addition there are various methods of dental notation involving different types of odontograms in current use throughout the world, which can make interpretation of the contained information difficult and confusing in some instances.

The availability of ante-mortem dental records can prove to be a great problem. In the Mt Erebus investigation, the ante-mortem information, including dental records, was still arriving from overseas five weeks after the actual disaster, even though the request for this material had been initiated within 24 hours of the crash[9]. In this type of situation the time taken to collect and transmit dental information can cause delays in the identification process[34,95]. The reasons for delay are typically due to circumstances such as difficulty in locating the victim's dentist, reluctance by dentists to forward records, failure to appreciate the necessity for speed in forwarding information or the necessity to pass the record through one or more intermediate agencies, and the forwarding of selected records rather than full records[34].

Even though the reliability of dental evidence has been acknowledged in courts of law[99], its usefulness is compromised by poor quality dental records or to the inability to locate the dentist responsible for the work in question[95,100]. These problems will continue to exist since many countries have no formal system of record keeping. Even in cases of overwhelming, complete and substantial post-mortem dental evidence, if there is insufficient or inaccurate ante-mortem dental information, investigations may be brought to a standstill, no conclusion reached and therefore no identification made[58,98]. Siegal, Sperber and Trieglaff in 1977 reported that even though there were about 3,500 medical examiners and coroners offices throughout the United States, between 5,000 to 7,000 unknown bodies per year remain unidentified primarily due to difficulties in locating ante-mortem dental information[101].

Ante-mortem dental data may vary in quality depending on access to the original records, the way they were kept and the relationship of the records to the time of death. For example, in the "Green River Murder" identifications, many of the victims had excellent dental records when they were children, but the post-mortem remains were those of young adults. The use of aliases, false birth dates, and transient lifestyles also presents difficulties in the acquisition of accurate ante-mortem records[36,102,103].

The inaccuracies of dental chartings provided to the forensic odontologist are depressingly common. These include the use of personal abbreviations, poor handwriting, the recording of wrong restorative materials used as well as errors in charting. Dentists can record charts in different way. Some may record only treatment required or treatment actually completed. Incomplete dental history results from failure to chart the complete dental status of patients who have been treated by other dentists whose identities are unknown.

All such findings have to be fully recorded and if any doubts exist they must be expressed. This is a requirement of the law, where the evidence should be in the form of facts and any discrepancies must be explained. Sometimes investigating personnel have found that dental records were destroyed because of restrictions on storage facilities, also some dentists do not see an obligation for proper record keeping as part of their service to the patient, or recognise that later records may be required for identification. This provides a considerable burden on the forensic odontologists and lengthens the elapsed time from discovery to the successful identification of victims.

The use of different methods of tooth notation may also generate problems for the dental identification team[104-110]. There are over one hundred different methods of charting in current use throughout the world (Appendix 7.1)[111-118] and as dentists universally do not agree to acknowledge the preeminent advantages of a particular system, this can only serve to confuse, especially during a comparison process. In the New Orleans crash of 1982, there were 154 victims from 15 different countries and the dental records recovered contained nine different types of dental charting.

Frykholm and Lysell published the results of a study of the most common systems used for registration of the teeth and surfaces[106]. The study covered the years between 1953 to 1959 and included 35 countries in all parts of the world. They concluded that the great majority of systems fall into two categories, those having a similar notation for the teeth in each segment, and those using a different notation. The systems were originally designed to designate the permanent dentition but later a complimentary system for the primary dentition was established, often by an addition to the symbol used for the permanent dentition.

Furthermore, dentists normally describe or enter their findings and treatment in an abbreviated or coded form and may also record them in pictorial or odontogram form. Whichever method is used is largely dependent on the legislation governing the method of dental record keeping and the standard of dentistry in a particular country. The odontograms sometimes differ not only between different dentists but also between different countries, even though they contain the same information (Appendix 7.2)[119-122]. This variation in methods requires thorough knowledge on the part of the forensic odontologist in order to avoid misinterpretation of records[123].

The variation in dental nomenclature was addressed when the Federation Dentaire Internationale (FDI) proposed a standardised or uniform method of dental charting during the 58th Annual Session held in Bucharest in 1970[124-126]. A Two-Digit System of tooth designation was submitted to the special committee, the FDI Working Group on Forensic Odonto-Stomatology (WG-FOS chaired by S. Keiser-Nielsen), by Dr. Jochen Viohl of Berlin who had been using it for some years in computer data handling. The assembly resolved a resolution by this committee with 38 votes in favour, 11 against and 7 abstentions.

The importance of intact and accurate ante-mortem dental records for military personnel has been emphasised by several authors[27,37,50,57,59,98]. Numerous contributions to the literature, illustrating the value of dental records in the identification of service personnel killed during wars, range from John Talbot, Earl of Shrewsbury who died in the Battle of Castillon (1453)[127] and Charles the Bold who died in the Battle of Nancy (1477)[128], to those who died in more recent conflicts such as the Desert Storm Operation in Kuwait in 1992[129], Somalia between 1993 and 1995[130] and Bosnia in 1995.

Dental records serve as the primary medico-legal documentation for military dental care provided, and as a baseline reference for recording dental defects that existed prior to military service. In addition, they serve as the most immediate primary resource of ante-mortem dental information, in the event of a deceased member of military personnel requiring positive identification via forensic dental means[50]. It becomes an obligation for every dental officer to assure that the information recorded is highly accurate, not only in the entry-level clinics, but in all Armed Forces Dental Centres (AFDC). Accurate recording is important to ensure that the patient is fully aware of the nature of the treatment proposed and the risk involved. Also, accurate recording is especially important as evidence in any malpractice cases[131] where a clear, comprehensive record of treatment is required.

In the United Kingdom, United States and Malaysian military, dental records are hand written upon a dental card, in some cases on paper or in a book and subsequently typed[79,119,130,132]. They are kept together with medical records in a locked room or security store to prevent damage or destruction. This allows ready accessibility and minimises the chances of loss. However, service life does pose some administrative dilemmas. Sometimes military personnel are allowed to carry or store their records with them especially during deployment to remote or dangerous locations[133,134].

Frequent moves or just regular postings, service in remote areas and the disturbance of war, make it more difficult for multi-service practitioners to keep excellent records securely. The possibility of loss, especially during sea service, is greater than it is in the civilian population, and the degree of risk becomes worse during war[132]. At the same time the lack of a central registry of dental records for information retrieval when information is widely spread poses an obstacle to dental identifications in the military services.

The bombing of the US Marine Headquarters in Beirut, Lebanon occurred in 1983, by a single suicide commando who drove his explosive truck into the Marines building, where at least 241 personnel were killed[135]. Due to the effect of the blast and the impact of the collapse of the building, many of the human remains were mutilated, charred and fragmented. The dental and medical records located in the bulding were severely damaged and some were destroyed. Many of the records sustained water damaged, were torn and had sand impregnated into them. The inadequate ante-mortem dental records and the condition of the remains were a problem for the identification team. However, 239 of the victims were identified using various methods of identification including dental identification as shown on Table 2.8.

The availability and the accuracy of some military dental records has been shown to be less than optimal. A study was published on dental charting accuracy in the United States Navy in 1970 and 1990.

Alexander[136] reported a total of 435 errors found in 140 dental records. Only 21% of dental records were error-free in 1970. The recent study in 1990 revealed that 24 of 85 Navy dental records (28%) contained a total of 57 charting errors. Alexander warned of possible difficulties in future identification because of the inaccuracies in charting and inadequate means for the retrieval of ante-mortem records which places a burden on military forensic odontologists. He suggested that additional methods be applied to upgrade military dental records for the future.

Table 2.8 Identification of the victims of the bombing of the US Marine Headquarters, Beirut, Lebanon.
Source: Gillespie, Brannon, Grayson and Gardner (1985)

Method	Total Identification	Total (%)
Dental and Fingerprints	131	54.8
Dental Only	68	28.5
Fingerprints Only	28	11.7
Medical Only	6	2.5
Visual Only	3	1.3
Dental and Medical	1	0.4
Medical and Fingerprints	1	0.4

Following the Beirut bombing case of 1983, Gillespie *et al.*[135] offered some recommendations applicable to all military situations:

1. Do not allow military members to carry or keep the original dental record.

2. Make duplicate dental records for military members who are to be deployed to potentially hostile environments.

3. Establish a central repository of dental records and radiographs.

4. Prosthetic removable appliances should include identifying information.

5. Diagnostic panoramic and full mouth, bitewing and periapical radiographs should be taken and securely stored.

6. Dentists should be included as members of the Remains Identification Specialist Teams.

7. Identify dental officers with mass casualty experience.

8. Formulate mass casualty identification teams.

9. Utilise the minimum number of dental personnel necessary to accomplish the identification task effectively.

10. Work no longer than twelve hours per day to decrease the probability of error and increase efficiency.

An armed forces dental officer may be requested to provide dental assistance in the forensic identification of unidentified bodies. It is a responsibility which applies especially after fatal accidents which result from mass disasters, or aircraft crashes where a large number of bodies are involved and when accidents occur which include military personnel. The dentist may be requested to participate and become involved in the whole process from the search and recovery through to identification of the remains. Dentists should plan and supervise the recovery of dental evidence, conduct the post-mortem examination of the dental remains and the acquisition of ante-mortem dental records of the individuals suspected to have been involved in the accident.

Haron, Brown and Taylor[130] have discussed the significant improvement in forensic identification of military casualties that can be achieved by inclusion of dental identification teams. They also described the importance of adequate and accurate ante-mortem dental records and radiographs as the primary means utilised in establishing identification. They acknowledged the difficulties that may be faced by the military dental identification team where mass battle casualties are involved. In this situation, manual sorting of the dental records is not adequate and more sophisticated methods of computerised records management are required such as a central registry where dental records can be stored, retrieved and transmitted efficiently. This would allow for immediate sorting and processing of available data for the comparison process.

A useful resource to assist in the rapid location of ante-mortem dental records and communication between forensic odontologists throughout the world is :- THE WORLD-WIDE LIST OF FORENSIC ODONTOLOGISTS prepared and published by Dr George E Burgman, 6288, Clare Cres, Niagara Falls, Ontario, L2G 2E1, Canada.

2.3 CODING AND MICROCHIP IDENTIFICATION SYSTEMS

A number of methods have been proposed and used to reduce the potential failure of the identification process when inadequate ante-mortem information is provided to the identification teams. One such source of failure is the difficulty in using the oral cavity as a means of identification in an edentulous individual, especially in cases of incineration. There have been a considerable number of victims who wear partial dentures and many wearing full dentures. If the dentures were marked or labelled in some way it would significantly help to establish the owner's identity.

Humble presented a comprehensive paper on identification by means of teeth during the Eighth Congress Dentaire International in 1931 and suggested some action which would increase the use of teeth as means of identification[89]:

1. When a body remains unidentified, a dental surgeon should be called in for examination of the teeth and jaws.
2. Dentists should keep careful records of work done.
3. Each denture should be stamped or marked with the dentist's personal stamp received from the police authorities.

Haines, in 1973, discussed the importance of denture marking with reference to 18 publications and an evaluation of 8 mass disasters[137]. These disasters produced a total of 380 victims, of which 50 victims (13.2%) had complete dentures and 47 victims (12.4%) had partial dentures. However, only 7 out of 97 dentures (7.2%) were marked enabling the victims to be positively identified.

Various forms of identification attached to dental appliances or to the teeth have been suggested for identifying individuals[1,138-141]. Carlsen (1933)[142] and Kruger-Monsen (1962)[143] cited by Gustafson in 1976, proposed that dentures should contain the name of the dentist and an identification number or a security number of the patient. Later this system was adopted by the US. Air Force School of Aerospace Medicine as reported by Jerman in 1970[144]. Lose (1958)[145] and Woodward (1970)[146] also suggested the incorporation of the patient's name in the denture marking.

Davis in 1982 suggested a standardised identification method for complete dentures by placement of an invisible number within the denture using lead or X-ray foil 0.001 inch thick[147]. Mayclin (1984) cited by Hansen (1991) suggested the use of clear plastic discs for use with removable dental prostheses[148]. This device carried typewritten or hand lettered data on a thin microdisc for individual identification and would be inserted into a slot in the denture. However, this carrier will shrink with heating thus reducing the size of the carrier and indices or in some incinerated cases lead to the microdisc being destroyed. According to Haines[137], edentulous people constitute only a small percentage of the population and so more reliable forensic methods which are universally applicable to dentate and edentulous patients are most important and increasingly needed.

Later research was aimed at eliminating the necessity for ante-mortem records for personal identification. Samis in 1975 introduced the concept of the Dentify System for personal identification[149]. He placed a modified identification pin as a marker, and a ceramic microchip under a filling in a tooth to make it radiographically unique. However, in restorative dentistry a small indentation on the marker may not represent a sufficiently distinctive signal and may not be clearly recognisable on radiographs as the constricted pin originally placed in the teeth.

The system proposed sometimes may not be compatible with the radiopacity of crowns or extensive restorations and may be dependent on the removal of an overlying restoration. In some cases it also requires scanning electron microscopy and x-ray equipment in order to be detected, especially in the examination of incinerated teeth. Such equipment is not always available to the identification team, and these procedures may add unnecessary time to the identification process.

Muhlemann, Steiner and Brandestini in 1979 presented the Swiss identification system, an encoded gold information disc implanted within the enamel of the tooth and embedded in fire resistant red composite material(150). The characters were engraved as a series of dots on the gold material. They claimed that this system permitted a rapid and positive identification by eliminating the necessity for locating ante-mortem dental records and avoided the delay in post-mortem radiographic examination. Later developments utilising dental micro disc technology used plastic and stainless steel chips inserted into and sealed within a tooth(103).

In 1983, Ellgren(151) (as cited by Hansen in 1991), introduced an enamel bonded intraoral micro disc for identification. This method of dental identification was suggested as an improvement over conventional identification systems. He used the Exact-I-Dent™, a stainless material which carried photo engraved characters and was embedded in clear composite bonding material at the time of insertion into a shallow cavity in the tooth.

Hansen in 1991 developed the micro identification disc using either a plastic or metal base for identification[152]. This micro disc carried computerised alphabetical/numerical type design with photo-reduced indices and was bonded to the buccal surface of a posterior teeth using clear resin by light curing or chemical polymerisation. This device, however, required the aid of a microscope or magnifier for the disc to be read and in some cases the lack of a marker may require a radiograph to establish the presence of the disc on the teeth. He suggested that in the future, it was essential to develop a micro disc with a standard format of coding, resistance to corrosion, external attrition, incineration and be of low cost for production.

The durability of the micro disc identifier has been studied by Wilson and Kolbinson in 1983[141,153]. They concluded that the ceramic chips are legible and withstand conditions following incineration at a temperature of 1,000^{0} C such as the circumstances following motor vehicle accidents. They suggested that computerised disc technology has the potential to resolve the identification problems of mass disasters.

Gladfelter in 1989 examined the retention and legibility of 20 polyester dental identification microdisks which were subjected to two conditions, a wet environment for 24 weeks or incineration under conditions found in an aircraft fire for 11 minutes[154]. Results indicated that 19 % to 65 % of the sample remained undamaged after 26 weeks in wet conditions with a confidence level of 95 %, and 16 of 20 sampled (80 %) under incineration conditions were found to be legible. They concluded that if microdisks can remain securely bonded onto teeth and be protected by 2.5 cm of tissue, they can be expected to remain intact in wet conditions or following incineration. A reasonable criticism of this system would be that few teeth are protected by 2.5 cm of tissue.

Sperber rejected the criticism of microdiscs as just another gimmick in addition to the identification process[140]. However, he acknowledged the difficulty in the feature because of variation in disc design and suggested the use of a single universal disc as more appropriate. According to Lorton and Langley micro identifiers may provide an indication of possible identity, however, the feasibility of such a system is questionable because[155]:

1. Will anyone realise that the implant is there at all?
2. Will that particular tooth survive during a disaster?
3. Will the equipment necessary to retrieve and read the disc or pin be available?

4. Will any country provide the money to make and maintain the device?

It would be a wise policy to use original dental records to confirm identification. Thus, the need remains for a reliable system to increase the accessibility, availability, accuracy and rapid transmission of ante-mortem dental records with a central records registry that will act as a clearing house for listing and storing of dental records. The possibility of establishing an ante-mortem and post-mortem dental record database for forensic identification purposes may be justified.

2.4 COMPUTERISED DENTAL RECORDS

Following the introduction of computers in dental clinic management their use has expanded greatly as the capability and capacity to process large amounts of data has improved. Scholle[156] emphasised the need to improve the speed and reliability of obtaining dental information when he noted that out of 40,000 cases of missing persons recorded by National Crime Information Centre (NCIC) in Washington DC, 2,000 to 10,000 bodies remained unidentified. He suggested that dental evidence should be computerised to facilitate retrieval.

The first computerised dental record systems to appear in the literature were in the early 1940's. The idea of using computer systems was suggested when Welty and Glasgow in 1946 illustrated that up to 500 cards with dental information could be prepared and sorted accurately in one minute using the International Business Machines (IBM) computer[157]. This system, however, required dental characteristics to be converted to numerical values adaptable to the IBM card and only selected characteristics such as fillings, missing teeth, crowns and bridge abutments could be included in this system.

It was suggested by Tattersall in 1947 that the Hollerith System of punch cards would be the most applicable in compiling dental data[158].

This system was applied in an effort to establish an international register of dental data especially for missing persons and personnel in dangerous occupations such as the Armed Forces, aircraft crew and people who fly frequently.

The Hollerith System seemed to be a great help in cases of questions of identity, especially in accidents which involved mass casualties. Petersen and Kogan used the Hollerith System to simplify the forensic identifications following the crash of an Air Canada aircraft at Woodbridge, Ontario, Canada in 1970[93]. The appropriate post-mortem information regarding missing and restored teeth, gender and age estimation was punched out on the card to be compared with the ante-mortem information obtained.

This system required the card to be transferred to a main computer by teletype. Unfortunately, it did not achieve the expected result, probably because of the lack of information regarding ante-mortem and post-mortem records (records of only tooth missing and restored rather than actual surfaces restored and materials used). Furthermore, there were too many casualties and too many specimens consisting of small fragments of jaws or teeth.

Attempts have been made to establish the use of computers for storage and retrieval of dental records which would apply in forensic identifications. The first and major step toward digitisation of dental recording was in 1970, when the FDI Two-Digit System for designating human teeth was adopted by the FDI and other international organisations. These included the World Health Organisation (WHO), Oral Health Unit for international dental epidemiology surveys, the British Standards Institution, the International Standards Organisation (ISO) and the International Criminal Police Organisation (INTERPOL) in disaster victim identification (Part I and Part J forms for the ante-mortem and post-mortem dental odontograms)[159].

The FDI Two-Digit System is well suited for computer handling due to the 2^n - Code System$^{\equiv}$ which applies for tooth surfaces[159] as shown in Table 2.9. This system has been used to establish a file of dental data from unknown missing persons and whenever dental records of known missing persons become available, it can be asked to pick out all the data sets which are on one particular tooth surface.

$\equiv$ Complete description of the 2^n - CODE System is in Appendix 7.1, section 7.1.4.

Table 2.9 The 2^n - CODE System for the tooth surface.
Source: Keiser-Nielsen (1982)

SURFACE	2^n - Code
O	01
M	02
D	04
V	08
L	16

Although the application of computer programmes for record keeping purposes does not seem to be directly related to the application of computers in forensic dental identification, there is a strong connection between these two systems. The computer will increase the efficiency in handling patient information and record keeping, which is important for medico-legal purposes. This method of record storage with adequate security precautions may help prevent loss or alteration which will be of great use for forensic identification[160,161].

The effort of computerising dental records in America was introduced in 1970 by Norman "Skip" Sperber, of the National Crime Investigation Centre and the Federal Bureau of Investigation (FBI)[97]. The system was quite simple. However, the method encountered vast problems, for example in the maintenance of up-to-date records. Later in 1977, Siegel, Sperber and Trieglaff completed their research by introducing a special charting system for entering dental records into a computer for storage and retrieval, incorporated with a comparison component which could be used for dental identification[101].

In recent years, there has been a developing interest in computerised databases for dental records. They have been successful in aiding identification of mass casualties where there were finite data with a known number of victims and known dental records[162-164]. The computer dental software used in the storing of dental records might help to overcome problems of lost or destroyed records. Such programmes would establish a rapid record retrieval system which allows speedy comparison or matching of dental records.

Various systems for both dental record storage and actual comparison of the ante-mortem and post-mortem data by computer have been developed and suggested. In general, the current concept of computerisation would establish a retrieval ante-mortem dental database system and a comparison programme available for a forensic dental identification team. It also facilitates communication by computer network, making it possible to transmit dental records and other vital data instantly to any location around the world.

Up to the present, many workers have produced computer programmes for dental clinic management systems including a dental records database system. Among these were Dr. Do-Little for Windows[165], A.T.S™ Dental System[166], ToothPics™ Patient Management System[167], DentalMac Practice Management System[168], MacSpecialist II Management Accounting Package[169], ULTIMA For Dentists[170], HI-TECH Dental Programme[171], Dentrix Practice management System[172] and Oasis. The detail descriptions of these programmes will be discussed in chapter 3, section 3.1.2.

Rada described a plan for the implementation of computerised dental data including storage, scanning, and hard-copy production units[173]. He claimed that this allowed maintenance and availability of accurate and up-to-date dental records. Ambrose in 1996 introduced the Dental Byte™ system for dental practice management[174]. It was claimed that this system enabled the practitioner to accurately store and retrieve a complete set of dental data including written records and dental images. This system also allowed quick, efficient and consistent on-line communication with other practitioners which would avoid duplication of dental records.

2.5 COMPUTER ASSISTED DENTAL IDENTIFICATION

> ***"Computers are certainly more efficient than men at some tasks but those tasks and their solutions 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."***
>
> **Lorton and Langley (1986)**

Over the last 25 years computers have revolutionised the way in which forensic odontologists carry out identification work and has led to the development of useful tools for the identification process. Computer assisted forensic dental identification is the application of computer technology to the identification process which involves the comparison of ante-mortem and post-mortem dental records. Computers provide considerable logical processing capabilities. Among these are effective storage, retrieval and analyses of large amounts of data, and the rapid and accurate execution of complex mathematical and logical operations involving large amounts of data without confusion.

In forensic applications, data handling capabilities are merged with algorithms to produce possible outcomes of equal or greater accuracy when compared with those done by the forensic odontologist. These capabilities should be viewed as an advantage in the handling of routine forensic cases or in cases requiring identification of mass disaster victims. Lorton and Cornwell(175) listed three important goals for the use of computers in disaster identification; information storage and retrieval, decision support and presentation graphics. The biggest advantage of computer-assisted dental identification is the time saved over traditional human sorting and comparison processes.

Rotzscher listed several computer programmes which have been in use in several countries, among which are OD(Sweden), VISTA (Norway), RITSYS (Netherland), Four Quadrant Method (Germany), IDENTIFY (Finland), ODONTID© (Adelaide, South Australia), IDENTIC (New South Wales, Australia), CAPMI (Army, USA), TOOTHPICS (Arizona, USA), IDENTIFY and Sonar professional (USA/Finland) and CRISIS (United Kingdom Police)(176).

The first forensic application of computers in the United States of America was in the Big Thompson Canyon Flood in Colorado, where 139 bodies were recovered and identified(177-179). This occurred in the early 1970's. The system used screen graphics to show the dental charting, which provided a useful tool in demonstrating to relatives of the deceased how an identification was made.

Following this incident, a number of applications have been explored and forensic odontologists all over the world have used different types of programmes to store and sort dental records of unknown missing persons for identification. Although the final decision will always rest with the forensic odontologist, a computer can serve as an important tool in the rapid sorting and comparison work in the identification process.

In 1974 the Computerised Aided Dental Identification (CADI) in mass disasters was introduced by Kogan, Petersen, Locke and Ball to assist the identification process[180]. The routine method of dental identification including the collection of ante-mortem and post-mortem dental records and comparison of both records is extremely time consuming especially during mass disasters, however, the process is within the capabilities of a simple computer programme. Kogan *et al.* applied the same logical steps to establish a computer programme for the purpose of aiding forensic dental identification.

This programme provided a system for storage of ante-mortem and post-mortem dental information concerning missing and filled teeth, and stored additional information regarding missing persons such as name, age, sex, and residential address which might subsequently be used for comparison. This system also allowed for the quick retrieval of the missing person's record and comparison using this information was carried out on the basis of teeth present and filled. The system was able to print all the possible matches of ante-mortem records with post-mortem records. Kogan *et al.* claimed that this programme would be able to recognise dental treatment that might have been carried out after the last available ante-mortem record was made, and would reject the possibility of any two specimens being from the same person if there was an overlap in the description of the teeth found.

The authors also developed this programme for ease of use. The hardware was sufficiently portable for use in remote locations and resulted in saving time spent previously in the manual comparison process by increasing the efficiency of storage, retrieval and comparison of dental data. However, it did not remain a dedicated instrument for long and the low potential of their computer system for use in storage and retrieval of large amounts of ante-mortem and post-mortem dental records was soon realised.

After comprehensive research by Siegel, Sperber and Trieglaff in 1977, a system was offered which they claimed was logical, reproducible and easy for the average dentist to use[101]. They suggested the need for a central computerised system for dental records for use in mass disasters and also for identifying individual missing persons. The authors described a new charting system in which the dental data could be processed in a computer. This programme allowed for the storage and retrieval of complete dental records for large numbers of at-risk people. This computer would operate with a comparison algorithm and be able to select the best match or matches and give the list of probability matching which could be used successfully for the identification process.

This system had been tested using 100 selected records which were incomplete and contained some errors in order to represent realistic ante-mortem records. The results reported the correct identification in 85 % of the cases. They noted and suggested that computerised dental records and forensic identification must allow for the following processes:

1. Easy input of data.
2. Easy updating and correction of stored data.
3. Rapid comparison between ante-mortem and post-mortem data.

4. Inclusion of a point scoring system that rewards correlative data and subtracts points where data does not match sequential possibilities.

5. Display and print out of the candidates and their scores in descending order of possibility.

Cirigliano reported the first use of a computer system for an air-craft accident in 1978[181]. The system was developed by Siegal *at el.* for dental identification of victims. A Pacific Southwest Airlines 727 jet collided with a Cessna plane, killing 144 passengers and all members of the aircrew. Ante-mortem and post-mortem data was gathered and encoded into this system which was specially programmed to allow a normal ageing of dentition from the fragmented remains. One hundred and forty victims were positively identified, with 110 of the victims (76%) being identified through dental means. This system was subjected to subsequent investigation to modify the programme, mainly using a bigger capacity of the database for sorting and storage purposes.

In 1980 Pierce *et al.* of Northwestern University Dental School introduced a computer code and programme for the input of dental data[133]. They claimed that this programme enabled the searching and matching of ante-mortem and post-mortem records by two different ways, either by a specific tooth or a combination of the records. The programme automatically counted the number of matches, noted the tooth number and listed the record of which match occurred most often.

This system was studied using 50 missing person cases and presented the result of 90% matching for items in pairs. When the same ante-mortem records were entered with minor alterations the number of matches dropped to below 50%. This reduction in matches was due to the inability of the system to allow for certain changes in the ante-mortem records. A programme which was more effective, easy to use and included self-assessment, was required to improve on the problems encountered.

During the Detroit aircraft accident in 1987, Warnick used the computer system devised by Pierce *et al.* to increase the speed of the identification process(97). This system also provided screen graphics to show dental charting which was helpful in explaining to relatives of the deceased how an identification was made.

The most important contribution to dental identification by the Federal Criminal Police Office in Wiesbaden, Germany was achieved by using Computer-Quadrant-Method as reported by Hagen, Endris and Wallmeier(182). This computer programme was developed in 1980 and has been in use since 1981. Computer-Quadrant-Method runs under the MS-DOS operating system which supports the functions of data entry, matching algorithms (comparison and selection) and reporting. The data were entered into this programme using the codes system shown in Table 2.10.

Table 2.10 The codes used for the Computer-Quadrant-Method.
Source: Hagen, Strack and Wallmeier (1990)

Codes	Description
ZA	Dental information from dentist
GM	Dental information from the forensic medical doctor
Alter	Age
M	Male
F	Female
K	Catastrophe
F	Missing teeth
FU	Filling
KR	Crown
BR	Bridge
TP	Partial denture
VP	Total denture
WF	Root filing
I	Quadrant in the upper right jaw
II	Quadrant in the upper left jaw
III	Quadrant in the lower left jaw
IV	Quadrant in the lower right jaw

In 1995 Hagen and Strack tested the matching procedures of the Computer-Quadrant-Method using the data of mass disaster victims who had been identified by dental means[183]. They claimed that between 96 to 100% of 80 cases were positively identified and that this programme allowed the easy input of data, correction and updating of stored data, rapid comparison with stored data, and the display and print out of all possible matches.

Solheim *et al.* in 1982 proposed the NOVA*STATUS programme, a text retrieval system for comparison work. This system was based on the British STATUS ONE programme which generates the teeth description as a sentence and the patient file as a document[184]. It enables the location of all documents containing either a specific word or sentence and displays the documents for examination and manual comparison. It was claimed that this system generated a simple, quick sorting of information to avoid error and overcomes lack of information which has to be dealt with by the computer. However, the authors admitted that this system is suitable only for routine forensic identification comparison and not in a large-scale disaster where it may be more time consuming than a suitably designed programme.

A test of the system was carried out by Dahl and Solheim following the capsized oil rig "Allexander L. Kielland" disaster[185]. A minor modification was found to be required. All the ante-mortem records collected were entered into a Honywell-Bull computer in order to compare them with post-mortem records in the original system. Some difficulties in regard to the ante-mortem information such as incorrectly noted tooth surfaces or material, different terminology used, and errors in data entry without using the odontogram made this programme less suitable for computerised comparisons. It was also revealed that one of the difficulties of this system was the search procedure which fails to locate multiple surface restorations (less suitable for data comparison). The authors also emphasised the need for a thorough knowledge of dentistry as a basis for decision making in the forensic identification programme.

A six-digit coding scheme was developed by Keiser-Nielsen in 1982 to simplify the establishment of ante-mortem and post-mortem dental files for Computer-Aided Dental Identification[186]. There were six codes available to describe each tooth. Two digits for designating the individual tooth, two digits for describing the surfaces (2^n - Code System or Two-in-the-Nth-Power System) and two digits for describing the type of treatment and material used (Table 2.11). However the accuracy of this system was difficult to confirm and the results were unknown.

Table 2.11 Six-digit coding scheme used by Keiser Nielson to characterise each tooth for Computer-Aided Dental Identification.
Source: Keiser-Nielsen (1983)

Six-Digit Codes System							
Teeth		Surface		Treatment and material			
1st+2nd digit		3rd+4th digit		5th digit		6th digit	
00	all teeth	00	intact	0	none	0	none
01	upper	01	O	1	filling	1	non-met
02	lower	02	M	2	inlay	2	amalgam
		04	D	3	crown	3	(1+2)
03 to	sector	08	V	4	RCT	4	gold
09		16	L	5	pivot	5	(1+4)
		31	OMDVL	6	pontic	6	(2+4)
10 to	second			7	dent/acr	7	(1+2+4)
49		96	no AM	8	dent/met	8	porcelain
		97	no recov	9	dent (7+9)	9	(1-7) + 8
50 to	primary	98	mis AM				
85		99	mis PM				
??			unknown	??	unknown	??	unknown

Keiser-Nielsen acknowledged the possibility of mismatches by computer systems when he wrote ".....the computer can give the best possibilities and written out in decreasing order of possibility, but they must always be compared by hand by the forensic dental expert, before final identification can result". This concept had been agreed by previous authors[102,184,187].

In 1982, Sakshaug explored VISTA(R), a menu-based programme which he observed could simplify the retrieval and comparison work for dental identification[188,189]. This system consisted of at least 24 lines and 80 columns which provided supplementary information including error messages and employed the FDI Two-Digit System of designation and coding of teeth and surfaces. The ante-mortem or post-mortem file could be established when available and data from either record could be entered to establish a search profile chart. This search profile would then generate the list of documents in a database meeting the requirements of the above chart.

This programme also contained Show, Edit, Sort and Print modes to allow all documents to be altered, modified, sorted and printed. He tested this programme on 400 post-mortem charts to compare with one search profile which he claimed required only 1.2 seconds to 2.7 seconds of processing time. However, the accuracy and efficiency of this programme was questioned by those who were involved in identification especially the abbreviation for treatment description and the ability to meet a search profile. Hence, a better understanding of computers for forensic dental identification became a matter of great importance.

Cohen, Schreoeder and Cecil in 1983 suggested the use of computer programmes for the military community in regard to forensic identification[132]. They had introduced computer readable cards which had been developed for use by the US Navy Dental Corps. This system was used to improve capabilities with respect to the computerised dental examination data as a permanent record and to provide matching algorithms for comparison of ante-mortem and post-mortem dental records where most likely matches could be rapidly selected in dental identification.

This system required a dental record database maintained in a given code and set as the pool of data for identification, which ideally could be in a central location to facilitate its use. This dental data could then be obtained by transmission to a computer system for identification purposes. Cohen *et al.* used an indexing procedure as described by Seigal *et al.* for the identification algorithm but which was different in the number of measurements, weighting factors (they used ratio [HIT-MODS/IMPS] whereas Seigal *et al.* used liner derived index [HIT-MODS]) and method of index to derive a short list of possible identifications[101]. They listed three possibilities that could exist:

1. ***HIT*** for any character which occurred at both ante-mortem and post-mortem.

2. ***MOD*** or modified for situations which may occur given a reasonable time interval between ante-mortem and post-mortem records. For example a tooth may be absent in the victim but present in the ante-mortem records.

3. ***IMP*** or impossibility which arose when a missing tooth was recorded in the ante-mortem but was present in the victim.

Possible identities were then ranked in order of probability by indexing algorithms based on the three scores, and this list is used by forensic odontologists involved in the case as a basis for positive identification. They claimed that this method of identification could provide identical matching capabilities with high accuracy and could decrease the time and cost involved in the manual method of identification of mass casualty victims but would not preclude positive identifications being made by the forensic odontologist.

Lorton and Langley of the US Army Institute of Dental Research (USAIDR) introduced the concept of creating searching criteria that would optimise a search through a set of records[155]. The designated features of importance were as follows:

1. Information must be in a standard form.

2. Data present must be in the same field on each record.

3. The same logical decision should be applied to the same data field for each record.

In 1983 Lorton and Langley developed the Computer Assisted Post-mortem Identification (CAPMI), a database management programme to assist with dental identification in mass casualty situations(163). CAPMI would accept the dental and physical records of an unknown identity or "key" records (post-mortem) and compare them with a database made up of equivalent records from a population at-risk or "object" records (ante-mortem). This system could sort 1,200 to 3,000 records a minute and give best match possibilities according to the maximum number of matches or minimum number of mismatches(98). They believed that this system could speed the identification by providing a list of most likely identities and reduce the number of comparisons made by forensic odontologists dramatically(190). They tested their system using 578 records and claimed 97% of positive identifications in the first and second place on the list of best matches and 99.4% in the first ten candidates of possible matches(163).

Daily in 1987 described briefly in his discussion the method of identifying remains from the Vietnam War using the CAPMI system[56,191-193]. This case involved the identification of remains of nine sets of commingled servicemen returned to the US by the Vietnamese government in 1985. Seven of the nine sets of remains were identified using the CAPMI system, which in this situation sorted through a dedicated database of all MIA personnel from the Vietnam War. At the CILHI more than 2400 records were short listed so that these highly probable identities could be used by the forensic odontologist to make final identifications.

Lorton, Rethman and Friedman in 1988 suggested some improvements in data handling to the original CAPMI system as a result of observations made following the Gander plane crash in 1985[194,195]. These changes included replacement of "virgin" charting with "data unknown" which they claimed would increase the possibilities of identification from 74 % to 83 % correct. However, the disadvantage of this programme is that the dental charting used the Universal Dental Notation system which is used only in the USA, requires double entry for charting, access is not automatically recorded in a visit log, and there are no transmission facilities for computerised dental records such as electronic mail for the external user. The programme used a coding system for teeth description and printed the list of ante-mortem and post-mortem record matches only and not the odontograms.

Further study to address which other factors would help reduce the weakness of the CAPMI system was done by Friedman, Cornwell and Lorton in 1989[196]. They introduced the use of a specially designed commercial Optical Mark Read (OMR) form or cryptic codes to input data to computers for the CAPMI system which allows non-computer experts to operate in a matter of minutes. Although this method could provide more than 80% accurate estimates for the identification, the authors also acknowledged the failure of the system to recognise and correct the errors while transferring the ante-mortem and post-mortem records using this method.

This question has led some workers to persist in an attempt to develop a computer system which would be tolerant of errors. Hashimoto, Nakano and Suzuki developed the "Canobrain Programme" in 1984 to substitute the traditional method of visual comparison, thereby eliminating human error[197]. They used a coding system suggested by Falkiesen in 1968 to run with "Canobrain Programme" for designating the status of a tooth and materials used in any restoration. In this system, data of dental records were divided to consider three situations, that is in air disaster victims, an unknown body and a missing person.

The results were reported as being 100 % accurate if ante-mortem and post-mortem records were the same or up-to-date, and if there were any changes subsequent to the ante-mortem records the results were reduced to 13 % correctly identified. The possibility became narrowed if the gender of the victim was taken into account and individual approaches tend to be more efficient.

Brown (1984) suggested that computers can assist in the identification process especially in cases of mass disasters, with multiple victims, where demands are magnified disproportionately to the increase in the work involved(198). Brown, Elliott and Hashimoto in 1985 introduced OdontID©, an MS-DOS based application which will run on an IBM computer with MS-DOS version 2.11(199,200).

OdontID© provided full on screen an INTERPOL standard odontogram graphic, utilising the FDI Two-Digit System notation, which required no precoding. It gave on-screen comparison odontograms for ante-mortem and post-mortem as well as between two jaws, and a printed record of the odontogram. OdontID© increased the speed of the comparison to three per second on a floppy based system and seven per second on a hard disk system.

OdontID© allowed a comparison to be made on the number of differences present between the post-mortem and ante-mortem records, and gave the list of possible identifications in descending order of probability. A combination of odontogram comparisons was then provided, for example upper and lower post-mortem and ante-mortem records and a printed record of the odontogram for inclusion in a formal report.

A comparison of the two computer systems (CAPMI and OdontID©), makes it apparent that the OdontID© programme is much simpler and easier to use by some one who is new to the programme, since it does not have the various combinations for description of the teeth, treatment done and material used to be coded in to the record.

Williams, Lorton and Friedman in 1990 introduced the hypothesis that, the searching for fragments with minimal numbers of mismatches could give the correct matches at a high rank of possibility in the new version of CAPMI(201). They claimed that there were significant improvements in rank place for the list of best matches especially for large numbers of victims with a high degree of fragmentation. They described a case of identification of a simulated disaster situation which took place in Warsaw, Poland in May 1987. In this test only 14 ante-mortem dental records were available to be compared with 112 post-mortem records and they claimed that the rank of the correct matches was better using the new concept. The time used to compare the database of 10,000 records was less than 12 seconds. The previous CAPMI system also provided too many ties for first in the rank order list.

Another computerised system presently in use in the United States is the National Crime Information Centre (NCIC)[202]. The FBI developed the NCIC system, a computer based identification system which stores information concerning the missing persons file and unidentified persons file. Dental data is an integral part of these records and information is stored concerning the presence or absence of teeth, restorations or caries present by tooth surface, removable appliances and other characteristics. The NCIC is used nation wide by local, state and federal agencies. It is in operation 24 hours a day, 7 days a week[203].

The importance of identification has resulted in INTERPOL and other forensic communities actively working to improve electronic data processing techniques to help in mass disasters. Tenhunen in 1990 extensively discussed Identify©, a Computer Assisted Disaster Victims Identification (CADVI) used by the Finnish DVI-Team[204,205]. This system was developed by Hannu Makela in 1989 based on the concept of Colonel Lorton and the CAPMI system of USAIDR. He used Turbo-

Pascal™ - Compiler and the programme has some advantages over CAPMI in certain aspects such as ease of use with a created dental status in graphics and text format.

A comparison was carried out in two modes; it either tried to find an ante-mortem record most likely to correspond to a certain post-mortem record, or tried to deduct if certain post-mortem records could have evolved from certain ante-mortem data. The system then gave a print out listing matches in order of the probability of the candidate fulfilling the criteria namely; Elimination (Mismatch), Uncertain (Possible), and Identification (Match). The author claimed that this system could create a connection to access a different database which is vital in order to shorten the time needed in the collection of ante-mortem and post-mortem data, but ignored the importance of speed in the comparison process.

Another computer assisted dental identification programme has been developed on a much larger scale and which is more efficient than previous systems. Prinz in 1992 introduced the identification programme written in TURBO-PASCAL 5.6, consisting of over 5,000 lines of codes, which provide three functions: data entry and error correction, matching algorithm, and report generation[(206)]. He added the error compensation by introducing the terms flipping, folding and compressing to match the sets of ante-mortem and post-mortem records.

1. Flipping compensated for errors in the chart between upper and lower teeth.

2. Folding compensated for errors between the left and right quadrants.

3. Compressing compensated for errors where the notation used for a tooth was confused with the adjacent tooth.

This programme analysed ante-mortem and post-mortem records to determine any differences within the acceptance limit of the stored data. He claimed that the computer could tolerate any alteration and changes to the ante-mortem records and was also capable of comparing two records taken at different times.

In 1995, the Belgian Disaster Victim Identification Team introduced the use of the computer programme IBIS to compare ante-mortem and post-mortem data[(207)]. IBIS was written in Clipper 5.2a and used database Clipper, Dbase IV and Dbase III+ (Clipper/CATOOLS linking via Blinker version 2). It was claimed that IBIS could achieve optimal identification by using all information about the victims, including personal identity and physical characteristics. A comparison is carried out by IBIS following certain rules and decisions, and presents a final score that gives an idea of the extent of total comparison and it's validity. The results are given by rearrangement of the target data in a top-ten order.

A Hierarchical Coding system for dental computerisation and reporting purposes was comprehensively discussed by Solheim in 1996[208]. He claimed that this system had been tested for the past 10 years in the Norwegian Centre register for missing persons and was found to be well suited for computer searches in forensic dental identifications.

The use of computer technology would certainly decrease the time and cost involved in the identification process. Since identification is a result of reasoning and logic, computers act as a sorting tool only and not a method to identify victims positively. Computer matching does not eliminate the need for direct examination of ante-mortem and post-mortem dental records and final identification and verification by the forensic odontologist. It merely helps to narrow down the number of possible candidates for more detailed matching of records.

Computerised cross matching programmes for forensic purposes have revealed a trend towards the use of increasingly comprehensive and complex data input systems. Among these was IDENTIC by Arneman, Wilkins and Griffiths in 1990[209] and "DAVID" or Disaster And Victim Identification introduced by Ceddia, Winship and Clement in 1996[210,211]. The detailed description of these programmes will be discussed in Chapter 3, sections 3.1.3 through 3.1.4.

The success or failure of all these computer database systems, however, depends upon missing persons being reported, time since the ante-mortem data was entered into the system and time elapsed before the unknown (deceased) person was recovered. Dorion stated that the need for computers to be used in forensic dental identification is determined by[54]:

1. The size of the disaster and the number of victims.

2. The number of specimens or degree of fragmentation of each victim.

3. The condition of the specimen either fresh, decomposed, skeletonised or mutilated.

4. The local conditions such as work force, accessibility, climatic conditions and space.

5. The accessibility to hardware and software.

2.6 DENTAL RECORD TRANSMISSION SYSTEMS

A number of methods have been proposed and used to reduce the delay in providing information to the forensic team, chances of data being lost in transit and to increase the accuracy and details of the information. Luntz and Luntz suggested that the original ante-mortem dental records should be reproduced before being sent to the forensic odontologist[212]. They described several methods used in the US for transmitting dental records such as Police conveyance, telephone transmission, postal services, airline parcel services and facsimile transmission systems. These methods, however, depend upon the urgency required, distances involved and facilities available.

The use of the telecopier transmission for the efficient communication of ante-mortem dental information was introduced by Vermylen in 1980[213]. Dental charts, photographs or drawings of the victims from all over the world could be transmitted by telecopier, provided it is prepared in suitable form and clearly drawn with the detail heavily inked for accurate, speedy forensic dental identification.

The use of telephoto as a means for accurate transmission of ante-mortem dental radiographs and photographs was suggested by Churton, following the Mt. Erebus crash in 1980[214]. This method also has the ability to work on telephone lines, satellite and radio to speed up the transmission. Images can be digitised, stored and transmitted using this system. These images require large amounts of computer memory and laser optical discs to store images in digitised form. It is a more efficient method of storing images than recording and storage of analogue film and photographs.

The printed images from this system, however, will not be as good as the original dental charts, drawings and photographs. Some loss and compression of dimensions will occur especially after reproduction steps and any errors made during the procedures cannot be corrected without reference to the original record. Only those who are experienced in using encoders and decoders are permitted to transmit the message in order to minimise or avoid any errors. Thus, Churton suggested that this system had many advantages but did not eliminate the need for the original ante-mortem records to be used when available.

Most of the computer systems for identification require a dental record database, maintained in a given code, as the pool of data for identification. This database could be maintained in a central location to facilitate it's use. In 1985, Southard, Baycar and Walter suggested the possibilities of using a computer system which allowed US Navy dental officers to capture and archive computerised ante-mortem dental records and transmit these records between central archives and a remote location[215]. This system would also be capable of capturing, storing, retrieving and displaying information on screen in a standard clinical format. It could improve the monitoring of patients, replacement of lost records, establishment of a recall programme, evaluate the treatment methods and materials and standardise the dental charting system used.

A connection between digitised camera technology in dentistry and the singular ability of computers to hold and manipulate large amounts of data occurred in 1986. The authors Southard and Pierce used a television camera to transform the visual image of a scene into an analog, composite video signal and then converted this signal into a digital value by using a video digitiser[216]. These digital images then existed as a data file which could be transferred to magnetic disk for storage. They claimed that this data file could be retrieved for display on a monitor screen or could be transmitted between microcomputers by using direct-connect modems over telephone lines.

In training exercises the transmitted images could be received at simulated disaster locations within minutes and the images were judged by the authors as having sufficient resolution for use in forensic dental analysis. This system, however, required communications to be established between the central registry and remote disaster or identification location. Also, a computer with a large memory capacity is essential to maintain accuracy and to decrease image transmission time.

Brown and Taylor in 1990 briefly discussed the use of facsimile for transmission of dental records and dental radiographs[217]. The radiographs were first transferred by laser copying to black and white prints which were then transmitted by facsimile. They claimed that this method enabled more rapid transfer of dental records (including radiographs) over long distances to the identification centre without loss of any important information, and that the transmitted radiographs were sufficient for dental analysis in the identification process. Farman and Farag in 1993 reported the use of electronic telecommunication systems for transmission of digital radiographic images[218]. This applied to direct digital radiography systems such as RadioVisioGraphy (RVG) and digitised conventional or analogue film radiographs. This system also allowed for picture archiving.

2.7 SUMMARY

According to General Patton: *"A good plan today is better than a perfect one tomorrow"*(219). Conversely, an ill-conceived and untried plan or no plan at all will almost certainly transform an incident into a catastrophe.

The ability to make a correct positive identification is an important aspect of forensic identification in modern society. The final outcome of identification depends on the ability to recognise, gather, preserve, organise documents and present ante-mortem and post-mortem information.

Even though dental evidence has been acknowledged in courts of justice as potential evidence the adequacy of ante-mortem dental records particularly in regard to their legibility, inclusion of relevant information, terminology and type of charting system can contribute to problems encountered during the course of dental identification. A number of methods have been proposed to overcome these problems.

The development of computers and modern technology has dramatically changed the traditional method for charting and maintaining dental records with a consequent impact on their value for dental identification. The computer assisted dental identification system dramatically reduces the extent of the work involved in mass disaster victim identification, which allows a dramatic increase in the speed of the procedures. However, the system relies on the existence of an accurate ante-mortem database and post-mortem findings for speed and efficiency.

In recent years there has been a developing interest in computerised database systems for both dental record keeping and forensic dental identification. However, the current computerised dental programmes deal with dental charting, and recording separately from dental identification. Some programmes may be difficult to access or they may be incompatible with available computer facilities.

Computerised dental programmes should be capable of standardisation with regard to dental charting, storage and back-up for replacement of lost records. They also should be able to access a dental database for ante-mortem records and then compare these with the post-mortem dental records. The comparison is then to be displayed on-screen with a list of possible matches and a print out of the odontogram to be included in the final report.

The advances in computer technology such as portable computer systems also allows rapid and easy deployment of computers to be used at remote disaster areas. Dental records (ante-mortem and post-mortem) including images (e.g. radiographs) can be stored, retrieved and transmitted between the central registry and a remote area or other computer systems for identification purposes.

CHAPTER 3

MATERIALS AND METHODS

Existing Dental Programmes
Materials
Methods

3.1 EXISTING DENTAL PROGRAMMES

3.1.1 Introduction

Computer technology is applicable to all aspects of dentistry from clinical dental management to the most complex of restorative procedures. Advances in computer technology have had an impact in the field of forensic dentistry, especially dental identifications in both routine case work and in mass disasters.

Many tasks in the forensic identification process are repetitive, time consuming, and very labour intensive. Thus, they are expensive to perform and usually occupy most of the time of forensic staff, but are essential to the final outcome of the identification process. Computers have the ability to perform rapid mathematical and logical processing, and unlimited memory potential has become the basis of this requirement. How these abilities can be applied to the forensic identification process is particularly relevant.

The areas where computer automation can be most useful for forensic dentistry include:

1. Dental office management which includes maintenance of available, adequate and accurate clinical records up to the most recent treatment or visit.

2. Computer Assisted Forensic Dental Identification in routine forensic cases and for disaster situations requiring multiple victim identification.

There is comprehensive discussion in the literature of how improvements to the identification process can be achieved through computer automation. Computer assisted dental identification programmes will perform a sorting and matching algorithm and give a short list of the most likely candidates for a final manual comparison by the forensic odontologist. This procedure does, however, rely on the existence of accurate ante-mortem and post-mortem dental records.

Furthermore, one of the advantages of using computers is as a link between the dental clinic and a central register which may handle all collection and storing activities and, when necessary, communicate with the forensic identification team. At present, within the Malaysian military environment the dental centres in each military base act as a central registry for that base. An ideal situation would be a controlling military central register based in Kuala Lumpur coordinating activities at each military base dental clinic. This proposal would also be ideal for forensic purposes within the civilian population, however there would be an issue of confidentiality and privacy with respect to this proposal.

Computer technology has great potential for information gathering. Coupled with this is the ability to manipulate data that is gathered, which can then be stored for later use and also there is provision for communication either through a monitor, printer or to another computer. This interactive database has application to wide ranging groups in the dental profession from government dental services, general practitioners to University dental faculties. This would ensure that the profession could share the dental information which is required for an efficient dental identification process.

The use of computers to generate correspondence and documents frequently needed in most dental clinics is an advantage for those time consuming and labor intensive tasks which need to be of a precise standard layout and content. Computers make such activities much easier and result in a consistent and good quality product.

Computerisation can also monitor clinical practice efficiency with dental software packages being able to generate standard clinical dental records based on internationally accepted dental notation systems such as the FDI Two-Digit System. Computerised dental office management packages are used to automate many of the repetitive time consuming tasks in the maintenance of dental data. This should increase the availability, quality and accuracy of ante-mortem dental records.

Thus, computers can improve the efficiency of forensic dental identification either directly by providing positive identification or indirectly through monitoring and storage of ante-mortem dental records, which allow the forensic odontologist to efficiently carry out forensic dental identification.

Existing computer dental packages are available in numerous specifications of varying speed, power, capabilities and requirements. The major problem is, therefore, in choosing the correct system for the current and anticipated needs of the forensic odontologist. Thus, the requirements for forensic odontological applications must be fully and accurately understood.

For this research, an understanding and appreciation of computerised dental record systems and computer assisted dental identification systems was gained by reference to a number of journal articles on the subject and by handling and using available existing programmes. Several features which needed to be considered were addressed in both computerised dental record systems and computer assisted dental identification systems. These included:

1. <u>General</u>

    a. Hardware.

    b. Design of the User Interface.

    c. Programming Language used.

    d. Database elements.

2. <u>Computerised Dental Record Systems and Computer Assisted Dental Identification Systems</u>

    a. Hardware.

    b. Software.

    c. Time efficiency.

    d. Input devices and input media.

    e. Design of the User Interface.

    f. Graphic display and output device.

3.1.2 Existing Computerised Dental Record Systems

3.1.2.1 Dr. Do-Little for Windows[α]

Dr. Do-Little for Windows 95 and NT was written originally for Disc Operation System (MS-DOS) application in 1987, for use with the PC-XT computer which was a 8086 processor running at 4.77 MHz using FoxBASE plus[(165)]. Later, in the 1990's, it was rewritten for Windows application using Microsoft Access database Version 2.0, which is part of the Microsoft Office Suite. It provides software which is extremely simple and easy to operate, permits programmes to be used concurrently and data can be transferred or shared between programmes (mail merge within Windows environment).

Dr. Do-Little was operated mainly using a pointing device (mouse) thus eliminating the possibility of errors introduced by use of a keyboard. It provides a field for dental and medical history, treatment plan, dental charting utilising the FDI Two-Digit notation system, performs basic accounting functions and allows for storage of photographs and radiographs. However, the disadvantages of this programme are that the dental charting system is generated manually using a paint brush

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α Dr. Do-Little for Windows is a trademark of Sanrix Pty. Ltd. a company with the address of 22 Bowes Ave., Edgecliff N.S.W. 2027 AUSTRALIA

α

programme and is not automatically included from written data (double entry); there are no transmission facilities such as electronic mail, it is only for a single user, there are no inventory systems for dental stores, no statistical analysis system, and no identification programme is included in this system.

3.1.2.2 A.T.S™ Dental System#

The A.T.S™ Dental System was written using FoxBASE Plus which is designed for use as a DOS application(166). It was designed to be easy to learn and use with a self-teaching system and on-screen tutorial for single and multi user systems. The scope of the software includes maintenance of patient accounts, correspondence, recall appointments, installment billing, accounts payable, general ledger and patient treatment records. The treatment record includes dental charting (utilising the FDI Two-Digit System), treatment plan and other clinical records.

The A.T.S system also helps in clerical and administrative duties such as suppliers systems (details of supplier and product) and wages and

A.T.S™ is a trademark of A.T.S. Practice Service Pty. Ltd. a company with the address of 26 Deakin Place, West Pennant Hills, 2125 NSW.

#

salaries by keeping all the records of staff and production of pay slips. However, A.T.S Dental System is only for a single user and is not compatible with a network environment or any other computer communication method which allows the fast transmission of dental records for identification purposes. It also does not have any comparison capabilities to facilitate forensic dental identification.

3.1.2.3 ToothPics™ Patient Management System⊗

ToothPics™ is a patient management system designed for the dental office. It was developed by Class One Ltd. Tempe, Arizona for use with the Apple Macintosh[167]. They claimed that this system provided dentists with complete software for the dental office which was as easy to use as "point-and-click" to enter patient information and run their practices. The system also provides individualised dental records with an on-screen dental chart that shows the condition of all teeth, utilising the Universal Notation System. The data is entered with a click of the Macintosh mouse, eliminating the need for keyboard entry.

ToothPics™ enabled the procedures entered on the dental chart to be automatically recorded in a visit log which included notes,

⊗ ToothPics™ is a trademark of Class One, Ltd. a company with the address of Class One Limited, 431 East Ellis Drive, Tempe, AZ 85282 USA.

recommendations, financial information, date and time of entry. It also provides comprehensive, understandable patient receipts with the American Dental Association (ADA) codes of fees recommendations and the cost for work to be performed; report of history, productivity, financial records and an opportunity for recall, and other correspondence. However the disadvantages of this programme are that the dental charting uses only the Universal Dental Notation System, there are no mail merge or network facilities, and no statistics or inventory programme. Also, it cannot run any other programme concurrently and has no comparison programme to facilitate forensic dental identification.

3.1.2.4 DentalMac Practice Management System

DentalMac is an item of dental practice management software developed by Healt Care Communication, Inc. USA, for use with Apple Macintosh computers(168). It is claimed that this system could provide the ability to process patient dental treatment records, statements and insurance claims, and that it maintains accounting financial data. It can also merge information with other Windows programmes such as Word processor, Worksheet, Database and others.

Furthermore, they described the ability of this software to process patient dental treatment records including dental charting, utilising the Universal Dental Notation System, patient dental and medical history; perform financial data, general ledger and accounts, and process correspondence, including statement and insurance claims. However, the disadvantage of this programme is that the patient records, including dental charting, utilise the Universal Notation System. There is maximum usage of the keyboard without auto generated or single entrance data facilities. It is mainly for a single user and no inventory or statistical programme can run concurrently. DentalMac has no forensic dental identification capabilities.

3.1.2.5 MacSpecialist II Management Accounting Package

MacSpecialist II is a management accounting package for dental professionals, developed by MacSpecialist Solution for use with Apple Macintosh Plus and the Macintosh SE II computer(169). It is claimed that this system provides the software for dentists wishing to streamline administrative functions. The features of this software were to store dental treatment records without the dental charting system, to process accounting functions such as accounts, receipts, day book keeping, bank deposit schedules and debtors ledger; and to process reports comprising account balances and outstanding debtors. This programme is more for clerical applications rather than for sorting, storing and identification procedures and has no forensic dental identification capabilities.

3.1.2.6 ULTIMA For Dentists[ϖ]

ULTIMA was written for windows using Microsoft Access database, which is part of the Microsoft Office environment. It provides software that is easy to use and learn by "point and click" and has an on screen tutorial system. It was developed by RAMGATE System Pty. Ltd. for IBM compatible computers and provides comprehensive patient treatment records and dental administrative functions[170]. It is claimed that this software could provide individualised dental records with an on-screen dental chart using a PaintBrush programme. The dental chart uses the Universal Notation System with a "point and click" system to record dental procedures.

ULTIMA can also process correspondence including reports, appointments, registrations and work schedules, perform basic

ϖ ULTIMA For Dentists is a trademark of RAMGATE System Sdn Bhd. a company with the address of RAMGATE SYSTEM SDN BHD, No 5, Jalan mamanda 7, Ampang Point, 68000 Ampang, Selangor Darul Ehsan, Malaysia.

inventory and storing programmes, can merge or share between Windows programmes and has facilities for single and multiple users. However, the disadvantages of this programme are that dental charting is via the Universal Notation System, double entrance for written records and dental charts is required, and dental charts are generated using paint brush in Windows. There is maximum use of a keyboard, no statistics programme is included and there are no forensic dental identification facilities.

3.1.2.7 HI-TECH Dental Programme

The HI-TECH dental programme was written using DOS application which was designed to assist the management of a dental surgery[171]. It was developed in New Zealand for the New Zealand Army Dental Corps in the early 1980's, and provided the dental professional with a comprehensive and understandable patient dental treatment record, financial report, inventory and storage system, and was suitable for single and multi-user computer network systems (Local Area Network only). This programme provided a patient odontogram utilising the FDI Two-Digit system for charting, however, it has no forensic dental identification programme capabilities.

3.1.2.8 Dentrix Practice Management System

In late 1995, New Image Industries Pty. Ltd introduced Dentrix, a simple integration of clinical and accounting functions for the dental profession[172]. The practice management software was developed for Windows and was claimed to deliver powerful, comprehensive features in the graphic presentation of the dental programme. It was claimed that this programme was easy-to-use and could provide a patient odontogram utilising the FDI Two-Digit system, ledger, intraoral images, digital x-rays, voice-activated charting and blood pressure monitoring. However, this programme is mainly for a single user and no identification procedure was included.

3.1.2.9 Dentech For Windows 95[Ω]

In early 1996 Health Technology Ltd. planned for the introduction of Dentech For windows 95, an advanced multi indexed database system which provides the basic data for dental practice management[220]. The scope of this programme includes a patient database with patient information and account details, an appointment register for single or multiple providers, a recall system for future planned income, and an

Ω Dentech For Windows '95 is a trademark of Class One, Ltd. A company with the address of Health Technology Ltd Private Bag 93228, Parnell, Auckland.

accounting system which allows for easy use with powerful functions for reports, and clinical records.

They claimed that the Dentech clinical records provide a detailed graphical odontogram of treatment history, treatment plan and completed treatment. Dentech provides the user with two data entering options; either the keyboard or the mouse. Keyboard entries are typed directly into the narrative chart, whilst the mouse entries are accomplished by clicking on the tooth surface and material used. However, this system does not mention or demonstrate the type of dental notation used and also has no comparison programme to facilitate forensic dental identification.

3.1.2.10 Oasis

Written using Windows which provides a dental surgery management system and is due for release December 1997. No copy of this programme was available for assessment[221].

3.1.3 Computer Assisted Dental Identification System

3.1.3.1 Computer Assisted Post-mortem Identification (CAPMI)

The Computer Assisted Post-mortem Identification is a database management programme developed by Lorton and Langley of the US Army Institute of Dental Research (USAIDR) in 1983 to assist with dental identification in mass casualty situations[163,175,194-196,201]. It is an MS-DOS based application which will run on any IBM computer compatible with MS-DOS version 2.0. They claimed that the programme could sort 1,200 to 3,000 records per minute and would accept input from the keyboard using specially designed commercial Optical Mark Read (OMR) forms. It was claimed to speed the identification process by providing a list of the most likely identities and reduce dramatically the number of comparisons required to be made by the forensic odontologist personally.

It was reported that this system used uniform and consistent codes for dental description, provided an on-screen dental chart utilising the Universal Notation System, on-screen chart-by-chart comparison and generated an on-screen best match list of ante-mortem and post-mortem dental records. This system could give three possibilities:

3.1.4 "OdontID©" - A Computer Programme For Dental Identification

Brown, Elliot and Hashimoto in 1985 introduced a significant modification to computer assisted identification[199]. The OdontID© programme is a computer programme for dental identification which was written by T.R ELLIOT while working as a Research Officer in the Forensic Odontology Unit at the University of Adelaide, South Australia in 1985 under a special grant from the Australian Federal Police. This programme was initially developed to assist in single and multiple identifications by dental comparison, with special application to disaster victim identification[200].

The OdontID© programme was written in GW BASIC and consisted of two functional applications; a data acquisition phase and a comparison phase. The data acquisition phase enabled any operator to input a series of ante-mortem and post-mortem data. A keyboard was used and the process was facilitated as this programme used 'Natural Language' where no pre-coding of dental information from a worksheet is required. The comparison phase calculated the number of differences between ante-mortem and post-mortem dental records (an example as shown in Figure 3.9). This was based on 160 surfaces of 32 permanent teeth with the total number of 192 features for comparison. The least number of differences gave the best possible match as 0/192 differences. With the increasing number of differences the possibility of a positive match was reduced.

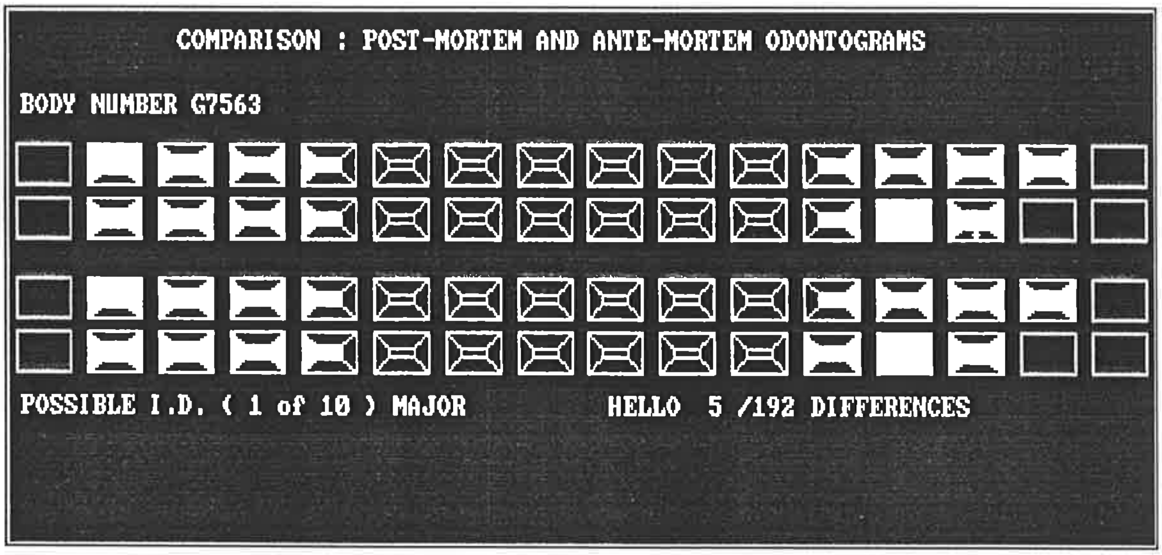


Figure 3.9 The comparison method utilised by OdontID© programme which depends on the number of differences between ante-mortem and post-mortem dental records.
Source: Brown, Elliot and Hashimoto (1985)

By addressing discrepancies which arise following a comparison, OdontID© will provide a result which has included all features which do not match and therefore reduces the risk of making a false positive identification. However, OdontID© does not provide a list of possible matches when multiple comparisons are made (e.g. mass disaster situations) stating different levels or number of discrepancies. It is important that any false negative matches that results from the comparison can still be revealed by further assessment of the results of the matching process, when all incompatible matches have been eliminated.

A choice of various functional applications and printing options are available. These include ADD records, UPDATE records, DISPLAY records, CHANGE work file, COMPARE post-mortem and ante-mortem records and END programme. The operator can examine on-screen dental odontograms or print them out for inclusion in the final report. These graphical odontograms include both ante-mortem and post-mortem odontograms, upper arch ante-mortem and post-mortem odontograms together, lower arch ante-mortem and post-mortem odontograms together and full ante-mortem and post-mortem odontograms (Figures 3.10 and 3.11).

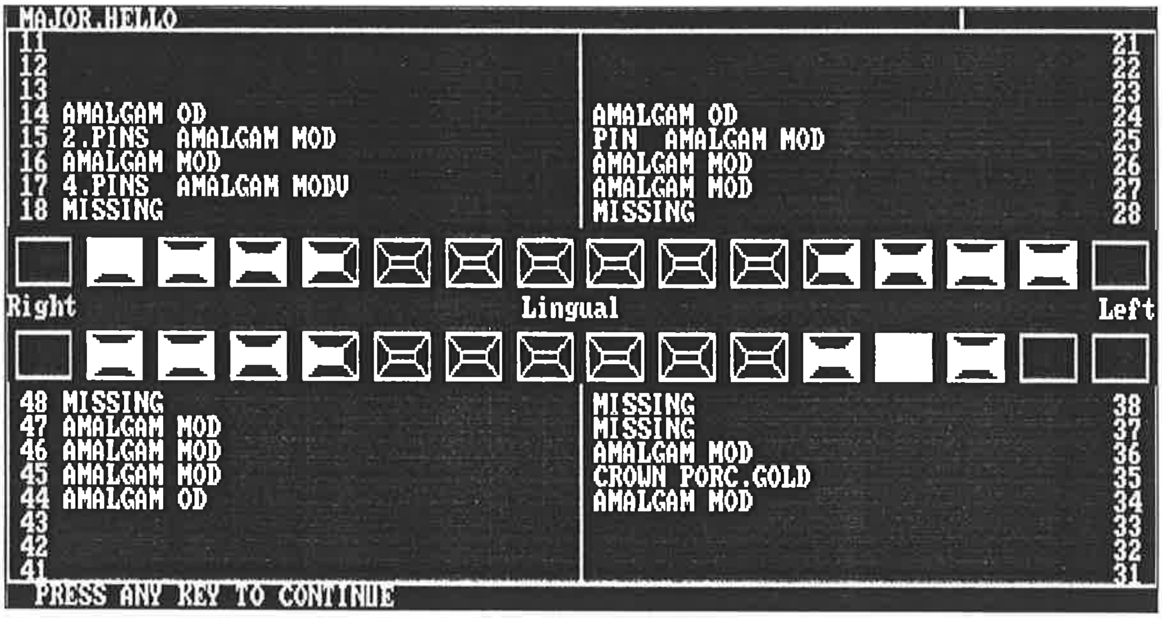


Figure 3.10 An example of the ante-mortem odontogram used by OdontID© programme.
Source: Brown, Elliot and Hashimoto (1985)

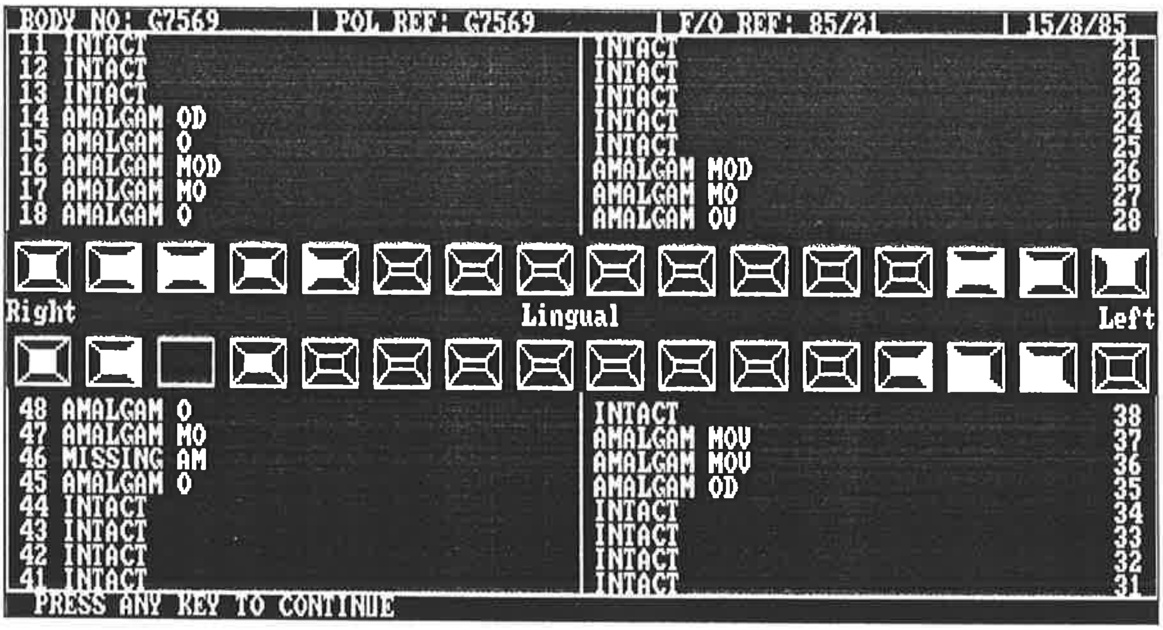


Figure 3.11 An example of the post-mortem odontogram used by OdontID© programme.
Source: Brown, Elliot and Hashimoto (1985)

Hardware used in conjunction with this programme was based on DOS application was originally written for the Olivetti M24 (AT & T) or any IBM personal computer, with MS-DOS version 2.11, minimum 256 Kilo byte RAM, 1 disk drive (min 1 Mega byte hard disk drive) for data storage and Epson RX80 printer. OdontID© programme provides full on-screen INTERPOL standard odontogram graphics, utilising the FDI Two-Digit Dental Notation System. It speeds the comparison process up to three sets of records per second on a floppy based system and seven sets of records per second on a hard disk system. Examples of execution of the OdontID© programme are shown in Appendix 7.4.

Other features of OdontID© include:

1. A programme which permits the graphic representation derived from written text thus reducing the human error in transcription.

2. It uses the function keys programmed for common dental restorative materials.

3. Expandable dictionary for new materials.

4. Provides a print out record of the 5 combination odontograms for inclusion in formal reports.

5. Provides a printed list of possible identifications in descending order of probability.

The disadvantages of OdontID© programme were that the software was developed only to be used with Olivetti M24 (AT & T) or any IBM personal computer which has 18 functional keys (where F18 is for print function). The matching processes could only show a result (odontogram) of the best matches for all four options:

1. All ante-mortem to all post-mortem.
2. Single ante-mortem to all post-mortem.
3. Single post-mortem to all ante-mortem.
4. Single ante-mortem or post-mortem to single post-mortem or ante-mortem (Table 3.2).

Table 3.2 A comparison of 1 post-mortem with 1 ante-mortem records (1/1) performed by the OdontID© programme.

RECORDS		TIME REQURIE	NUMBER OF DIFFERENCES
AM	PM	(min)	(192)
A	1	2.5	0
B	2	2.5	16
C	3	3	83
D	4	3	4
E	5	3	55
F	6	3	64
G	7	3.5	32
H	8	3.5	16
I	9	2.5	8
J	10	3.5	0

When using the OdontID© programme for multiple comparisons and comparisons of single post-mortem with multiple ante-mortem cases, it was found that the software provides a list of best possible matches only (top in the list), but no other possible matches for evaluation as shown in Tables 3.3 and 3.4. This severely restricts the interpretation of multiple comparisons and would be a disadvantage especially in cases of mass disasters. This problem can be overcome by using single ante-mortem record to compare with multiple post-mortem records (Table 3.5), however, this process is very time-consuming and inefficient. In addition the software gives the results of this matching process simply according to sequence of data entry and so provides no list according to best matches or degree of differences.

Table 3.3 Results of a comparison of 10 post-mortem with 10 ante-mortem dental records performed by the OdontID© programme.

LIST BEST MATCH		NO IN THE LIST	NO OF DIFFERENCES	TIME REQUIRED FOR COMPARISON (min)
PM	AM	(10)	(192)	
1	A	1/10	0/192	
2	B	1/10	16/192	
3	C	1/10	83/192	Test 1 = 81
4	D	1/10	4/192	Test 2 = 73
5	E	1/10	55/192	Test 3 = 62
6	B	1/10	63/192	
7	G	1/10	32/192	MEAN 72 min
8	H	1/10	16/192	
9	I	1/10	8/192	
10	J	1/10	0/192	

Table 3.4 Comparison of 10 separate post-mortem (1-10) with the same 10 ante-mortem records performed by the OdontID© programme.

	NUMBER OF DIFFERENCES (maximum 192)									
AM / PM	A	B	C	D	E	B	G	H	I	J
1	0									
2		16								
3			83							
4				4						
5					55					
6						63				
7							30			
8								17		
9									8	
10										0

Results in Table 3.4 are for the comparison of 10 post-mortem dental records using separate single post-mortem records with the same set of 10 ante-mortem dental records. The clear areas represent the values for the least numbers of discrepancies which are the only results given by each matching process.

Table 3.5 Comparison of the same 10 post-mortem with 10 separate ante-mortem records (A-J) performed by the OdontID© programme

NUMBER OF DIFFERENCES (maximum 192)										
AM / PM	A	B	C	D	E	F	G	H	I	J
1	0	3	53	61	24	43	76	53	3	56
2	19	16	62	73	36	55	84	57	16	67
3	111	112	83	125	125	137	137	123	112	138
4	65	64	85	4	76	83	108	79	64	72
5	63	61	88	80	55	79	97	76	61	83
6	69	63	105	103	66	64	125	87	66	93
7	64	63	90	98	76	89	30	97	63	9
8	49	46	70	70	52	699	97	17	46	66
9	8	8	56	62	28	47	76	56	8	61
10	56	55	93	69	61	73	95	67	55	0

The clear areas in Table 3.5 represent the values for the least numbers of discrepancies. The OdontID© programme has limitations in the comparison of multiple records. For the matching of a single ante-mortem record with multiple post-mortem record records, the ante-mortem dental data must be entred for each comparison made. The programme has no facility to retrieve any records for multiple comparisons, it is necessary to create a new file when comparing previously entred data for a new matching process.

3.2 MATERIAL

This proposed system works through MS Windows and Macintosh environments, has a graphic-orientated interface where the entire screen is a command line and a mouse or cursor can be used to move an icon symbol for an application. This will allow two or more application programmes to run concurrently, and within strict limitations information can be shared between two or more applications and users. The following recommended hardware and software specifications is a list designed to cover the minimum requirements to establish a proposed system that is within the user's control. The selection of ideal query entity types to be included in this study will be based on the criteria required by the Malaysian Armed Forces.

3.2.1 Initial Query Entity Types

Analysis of the system currently used by the Malaysian Armed Forces Dental Services revealed that at least 4 major entites were distinguishable as shown in Figure 3.12. These were: clinical data; departmental; utility and forensic dental identification. The minimum information that is required for computerisation within the Malaysian Armed Forces Dental Services and military personnel ante-mortem and post-mortem dental records to fulfil these requirements includes the following:

1. Filing of Departmental and Dental Records

   a. Department record
   b. Employee, Patient and Dependant record
   c. Work History
   d. Relevant medical history
   e. Charting system
   f. Diagrammatic Odontogram

2. Disaster Victim Identification

   a. Personnel Details - Name, DOB, unit, rank, body number and forensic odontology case number.

   b. Charting system - Victim identification form approved by International Criminal Police (INTERPOL) indicating teeth present, filled, decayed and denture (material and teeth replaced).

   c. Diagrammatic Odontogram - utilising the FDI Two-Digit Notation System modified to include deciduous teeth.

3. <u>Utility</u>

   a. Inventory system
   b. Correspondence
   c. Statistical analysis

4. <u>User Interface of Dental Programme</u>

   a. Application through MS Windows.
   b. Easy to open, use and complete.
   c. On-screen dental chart or diagrams.
   d. Point-and-Click data entry facilities eliminating the need for a keyboard and manual data transfer to text file.
   e. Toolbar menus for rapid information retrieval.
   f. Integration into existing computer.
   g. Simplicity - single entry and automatic entry into other files.

The schematic chart of the system to be included in the proposed computer programme for the Malaysian Armed Forces Dental Services is shown in Figure 3.13. Detailed description of these entities are show in Appendix 7.3.

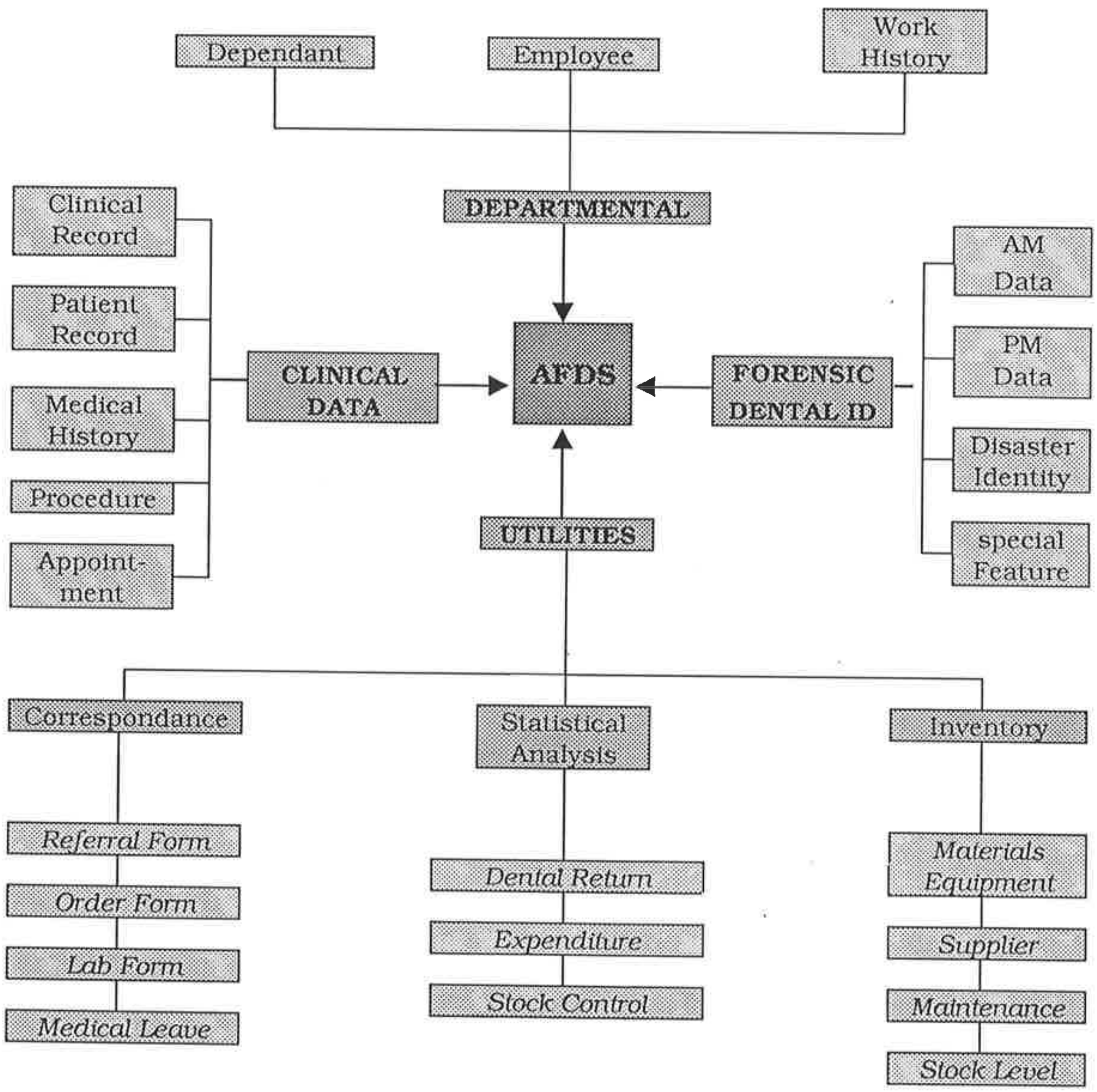


Figure 3.12 The Malaysian Armed Forces Dental Services scope of duties.

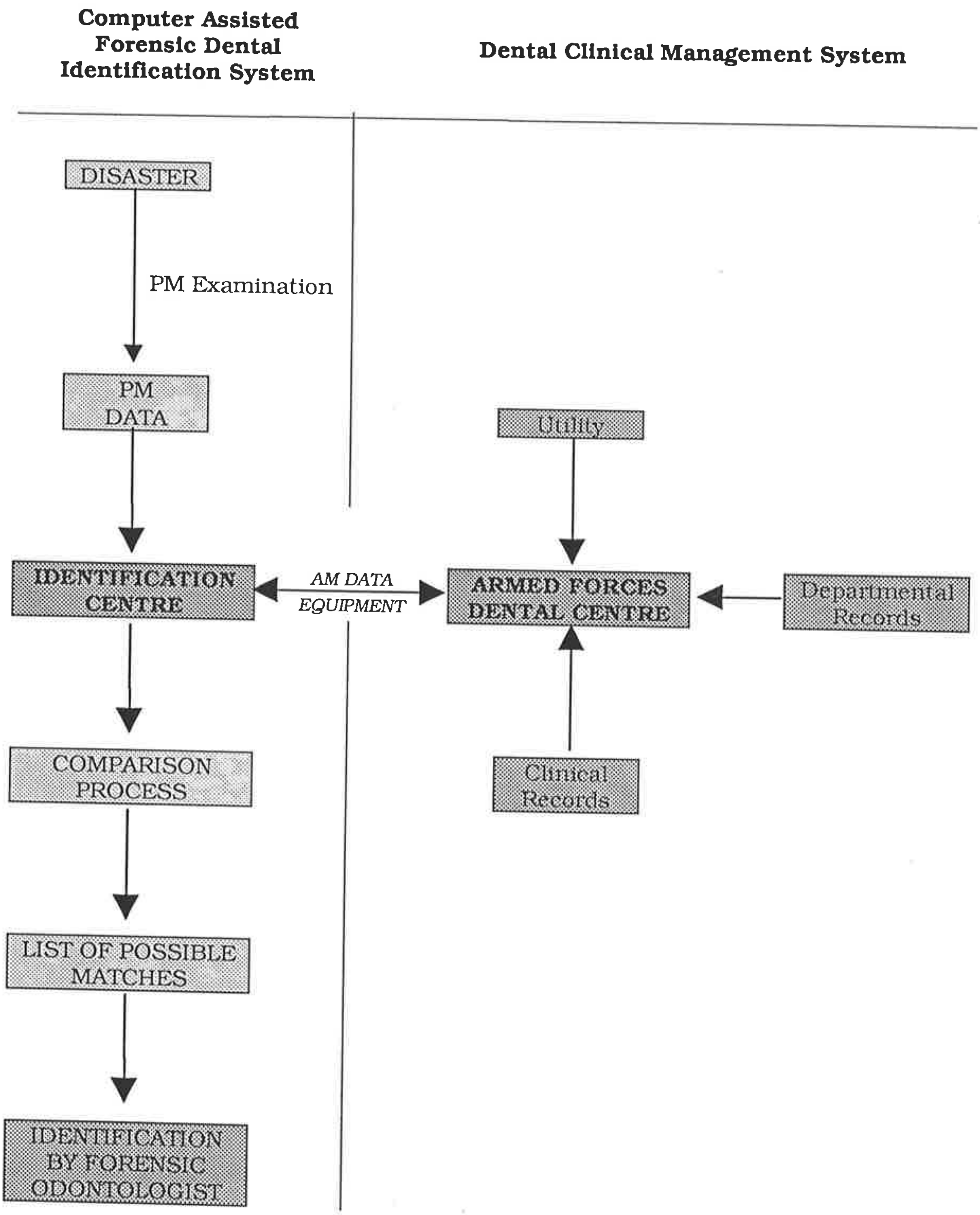


Figure 3.13 Chart of the systems to be included in the proposed computer programme for the Malaysian Armed Forces.

3.2.2 Hardware

1.	**Server:**	Unix/Sun, NT
2.	**DISK:**	Minimum 4.5 Gb
3.	**Server OS**	Pentium PC
4.	**Client OS**	Windows, 3.11, 95, NT
5.	**Scanner**	Colour Flat bed Desk Jet 2
6.	**Printer**	Min 300 dpi Laser

3.2.3 Software

1.	**Database:**	RDBMS, PARADOX, ORACLE, MS ACCESS
2.	**Web Server**	HTTP compliant server, ORACLE WEB server 2
3.	**Browser**	32 bit browser, 16 bit Netscape
4.	**Support Languages:**	HTML, C, C++, JAVA, scripting (eg: PERL)
5.	**Specific Needs:**	Software to view special data formats, Adobe Acrobat (PDF).

3.2.4 Internet/Modem

A Modem is a device that links a computer to the telephone line and allows the computer to communicate with a remote computer. It can be placed either internal or external to a computer. The term modem is used to describe two major functions:

1. Modulation. The process of converting the digital data stored in a computer into analog form. The data then can be transmitted via telephone line.

2. Demodulation. The process of conversion of the analog signal back to digital data to be read by a computer system.

3.2.5 Printer

A printer is one of the output devices for the computer.

3.2.6 Mouse

This is a pointing device that allows the curser to be manipulated on a screen which reduces the use of the key board.

3.3 METHOD

3.3.1 Overview

The proposed system is a general purpose forensic database system which has been designed to meet the requirements of forensic professionals and to be used in the Malaysian Armed Forces Dental Services. Version 1.0.0 brings the base elements of the system, being the forensic module. Versions 1.1.0 to 1.3.0 will incorporate the three final modules.

3.3.2 Design Rationale

For the new forensic database system to be a useful tool, it was imperative that as many users as possible should have access to the system concurrently. This system must be adaptable, as it is expected to perform in situations such as mass disasters. Furthermore, it was imperative that the system should use current technologies. To this end, it has been split into two main functional applications: one of the functional applications has been written for Windows 3.11/NT/95 and the other for Netscape based systems.

3.3.3 Operational work Horse

The Windows NT/95 functional application (WinNTFA) has been developed for two main purposes: Stand Alone System/Local Area Network (LAN) based Systems and Point of Incident (POI) data acquisition.

3.3.3.1 Stand Alone System/LAN based Systems

If the users of this system are either stand alone users of the software or if they are only using software in a LAN system configuration, then the WinNTFA module is all that is required. This, however, will be the more expensive method. There are advantages and disadvantages in all systems, and this is no exception. The advantage with the WinNTFA module, is that data can be maintained locally, the disadvantage being that the cost of the system is high, and it will be very difficult for outside users to gain access to the system. This disadvantages can be reduced by the Platform Independent Functional application (PIFA) module, which will be discussed later.

3.3.3.2 Point of Incident (POI) data acquisition

POI is one of the advantages of the WinNFTA module. It allows users to acquire information at an accident scene, or in the autopsy room. The system will incorporate touch screens and voice recognition technology. Furthermore, data can be entered onto the notebook version of the software and then downloaded into the main database.

3.3.4 Platform Independent Functional Application (PIFA)

PIFA acts as an extension of WinNTFA. It's purpose is to provide access to the new system database scheme although the data is not held locally. This version is primarily for those who do not want to spend too much money in acquiring a forensic system, but at the same time wish to utilise the power of the new forensic database system.

PIFA is executed within the Network environment (Netscape, Mosic and Windows Explorer) in which the user must have an Internet connection in order to use this application. Even though it is possible to have multiple data entry, the most important aspect of this new forensic database system is that the operator can also use multiple data searching. It presents the comparison data by direct comparison rather than relying on statistical methods.

The OdontID Professional© programme performs the direct comparison between ante-mortem and post-mortem dental records, giving the list of names of the potential victims and providing the number of differences between the post-mortem data of the deceased person and the available ante-mortem information. At this stage, it is left to the forensic odontologist to decide the final outcome.

CHAPTER 4

RESULTS

Method of Computation
Matching Algorithm

4.1 DISCUSSION ON THE METHOD OF COMPUTATION

The OdontID Professional© programme was developed to compute the Malaysian Armed Forces Dental Services through a combination of department records, clinical records, utility (inventory, correspondence, statical analysis) and the forensic dental identification system using MS Access 97 as the database engine and Access Basic (a sub-language to Visual Basic 4.0) for the user interface. The tables (entities) used in this programme are given in Appendix 7.3, section 7.3.1 through to 7.3.4.

This application is currently in its development stage, and hence all that will be described below is true for the prototype only. In the first release version, though, it will be able to function over the Internet, as Access 97 has the facility to export it's tables to an Internet Server without the application developers writing a single line of code. Access will export to Hypertext/Internet Database Connector (HTX/IDC) format or Microsoft ActiveX Server Page (ASP) format. The database must reside on a Microsoft Internet Information Server, or on the Microsoft Personal Web Server.

4.1.1 Some Simple Definitions

4.1.1.1 IDC/HTX files (Microsoft Help Files)

The Microsoft Internet Information Server uses IDC and HTX files to get data from an Open Database Connectivity (ODBC) data source and format it as an Hypertext Markup Language (HTML) document. The IDC file is a text file that contains information on how to connect to an ODBC data source and also contains a Second Quarter Language (SQL) statement to execute. The HTX file is a text file that acts as a template to specify how to format data as a HTML document when the data is returned from the SQL statement specified in the IDC file. HTX files are HTML files which contain keywords that control how data is formatted and placeholders specifying where that data is inserted in the HTML document.

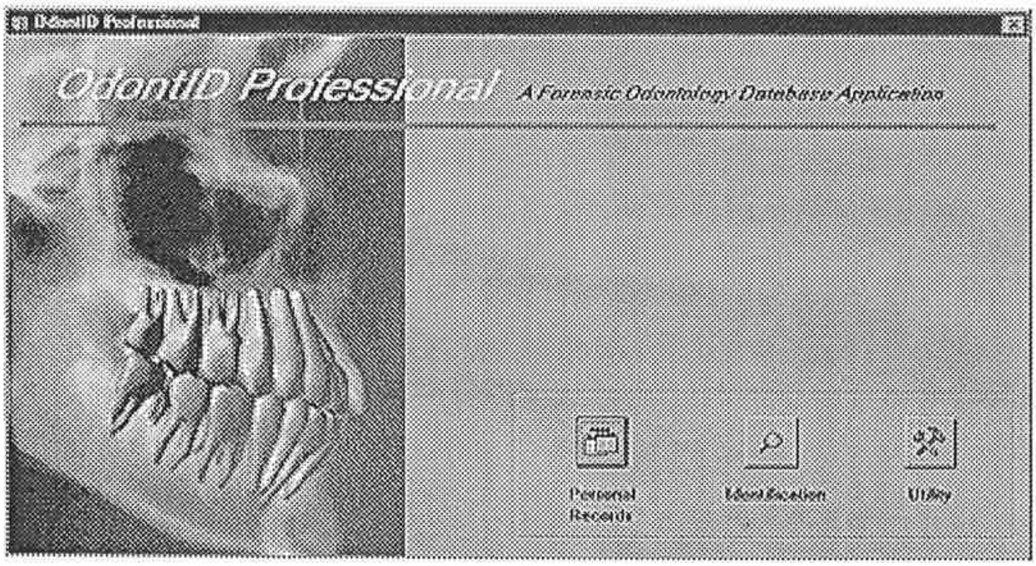
4.1.1.2 ASP files (Microsoft Help Files)

ActiveX Server, a component of Microsoft Internet Information Server 3.0 or later, uses ASP files to get data from an ODBC data source and format it as an HTML Web page. The ASP file contains server-side scripts that specify how to connect to the data source, as well as the appropriate HTML tags to format the data once it's returned. For a form saved as an ASP file, the ASP file also contains ActiveX controls and VBScript code.

4.1.2 OdontID Professional© Screens

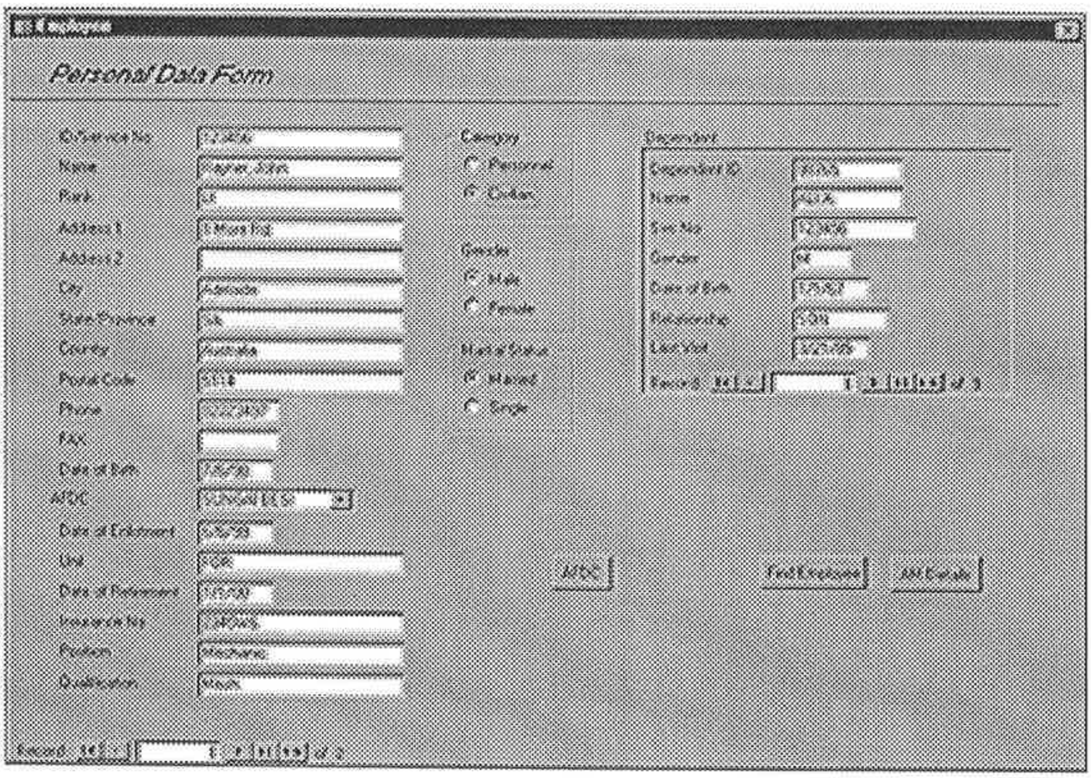
4.1.2.1 Main Screen

Below is a demonstration of the navigation screen for OdontID Professional©.



It's prime function is to guide the user through OdontID Professional©'s four main functional sections.

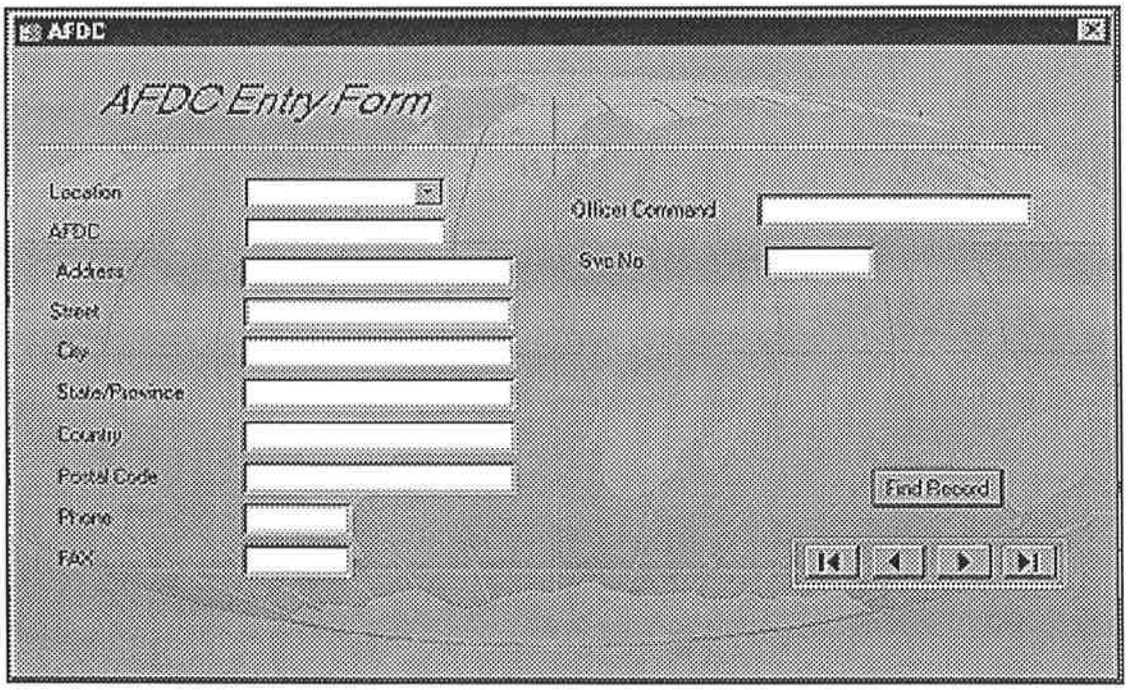
4.1.2.2 <u>Personal Record</u>



Upon choosing the Personal Record button, the user is faced with the Personal Data Form. This form is used to enter specific details about each employee. Each employee is related to the AFDC form by virtue of the fact that each employee belongs to different military organisations, within the Malaysian Armed Forces. The Personal form includes a button that allows the user to enter specific details about the personnels Dependant.

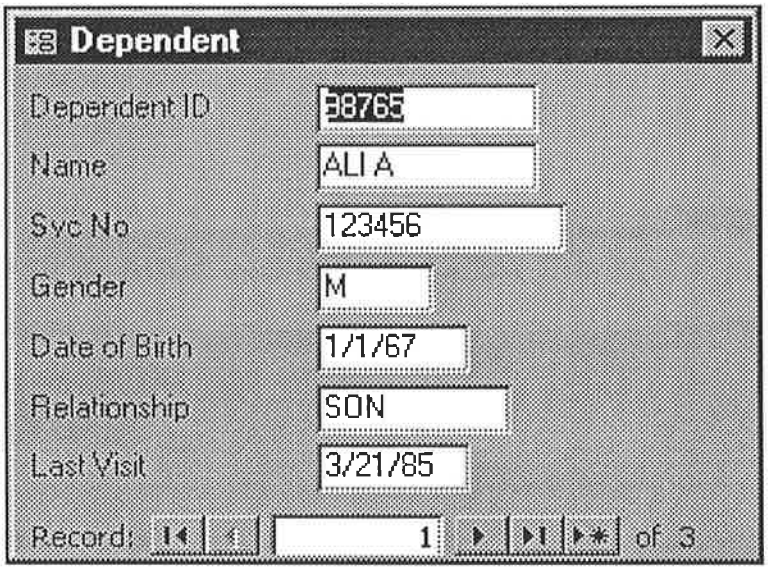
4.1.2.3 AFDC (Armed Forces Dental Centre) Entry Form

These forms are detailed as follows:



AFDC (Armed Forces Dental Centre) Entry Form is used to enter location details about each command centre in the Malaysian Armed Forces. This form allows the user to enter AFDC details and Officer Command details.

4.1.2.4 <u>Dependent Form</u>

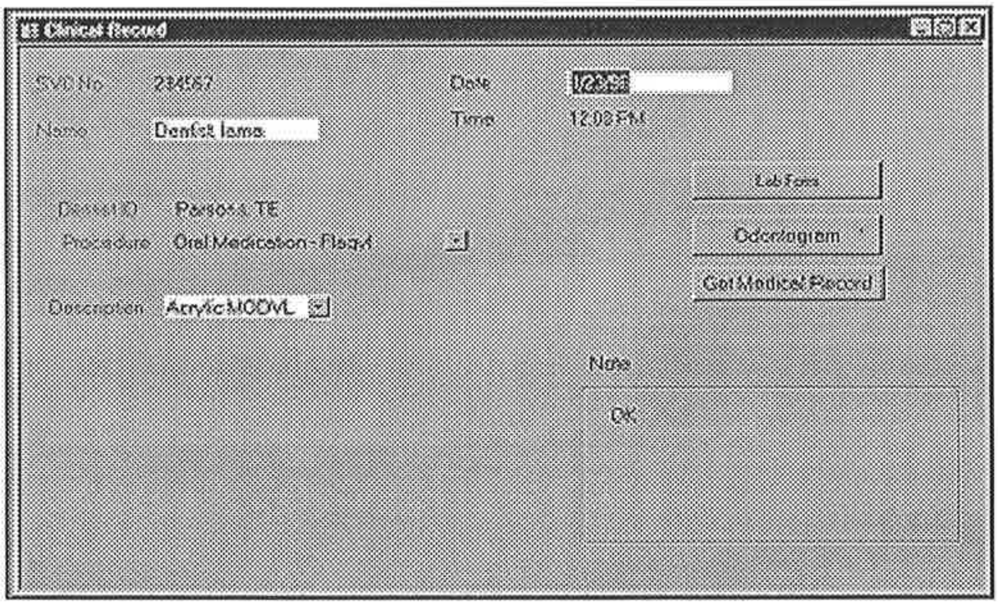


The Dependent Form simply maintains general details about each employee's dependents. This information is required for several reasons:

1. The Malaysian Armed Forces looks after the welfare of every employee's dependents as well.

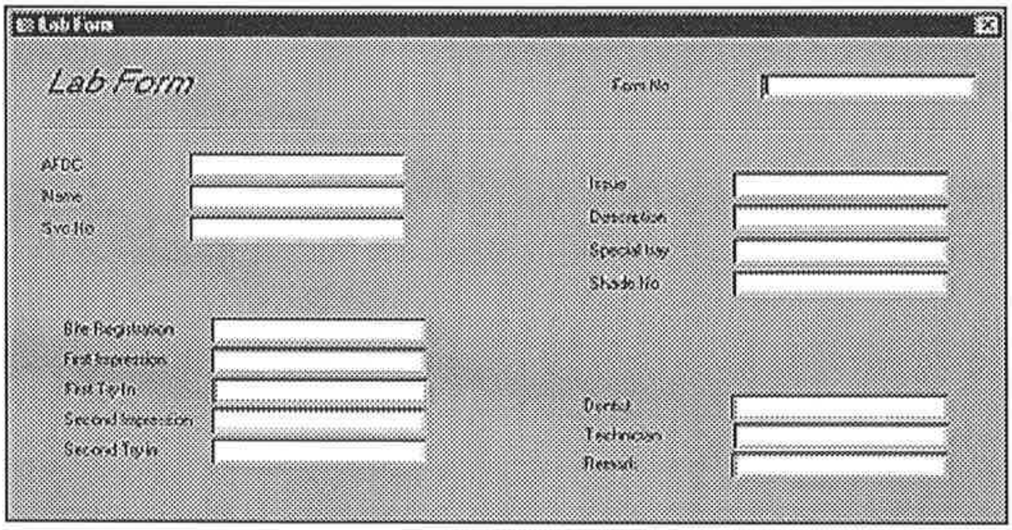
2. This information is used when the next of kin need to be informed of a death in the family.

4.1.2.5 Clinical Records



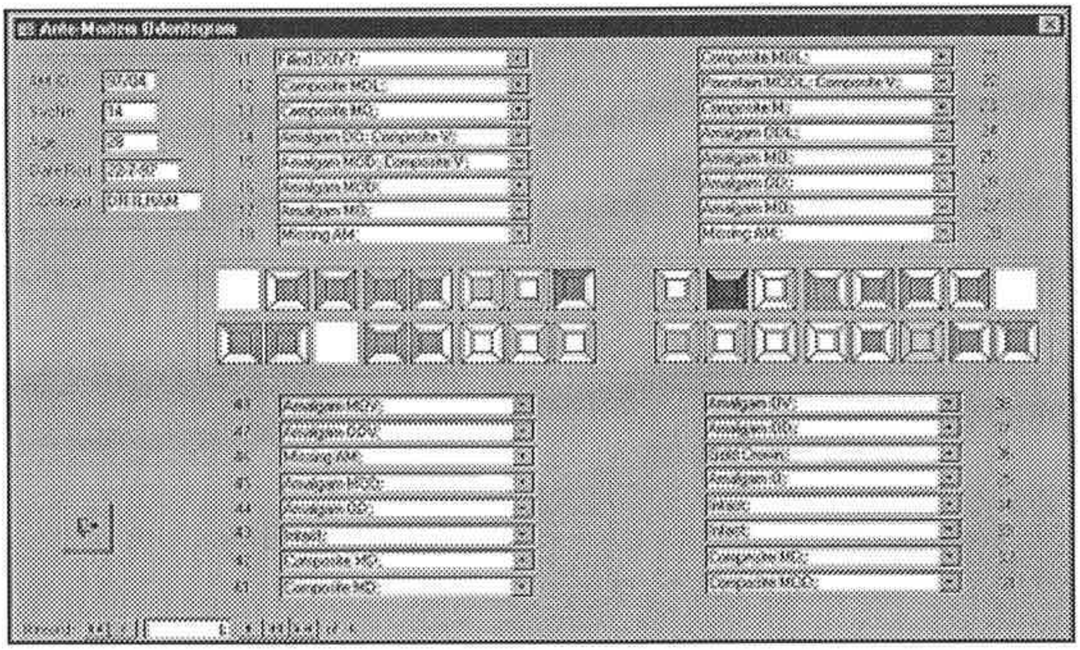
Each employee has a clinical record. From this form, it is possible to view the details of every treatment administered to the patient. It is also possible to fill out a laboratory test request form, view the patient's odontogram and look at their medical records.

4.1.2.6 Laboratory Form



This form is filled out every time a dentist requires a laboratory procedure to be initiated. This may include prosthetic work, crown and bridge work, orthodontic work or implant work.

4.1.2.7 <u>Odontogram</u>



Although this is a copy of the ante-mortem odontogram, all the odontograms in the application basically have an identical display.

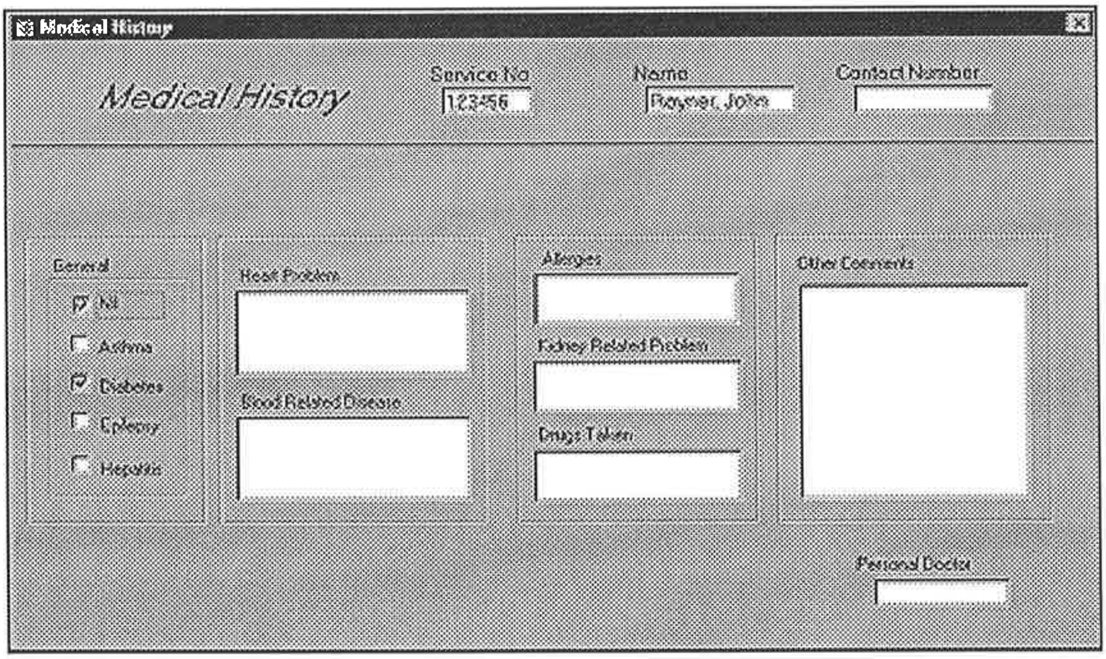
The purpose of this odontogram is to highlight the most recent state of an individual's dentition. Three major features of this form are:

1. Colour is used to describe the different treatments.

2. The User can add to the list any new treatments or materials not included in the standard list.

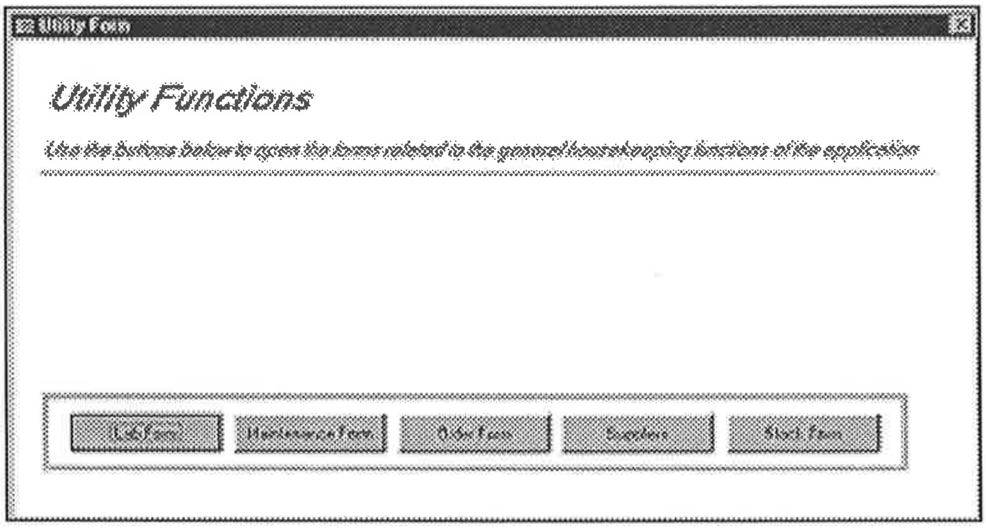
3. To alleviate the possibility of error, there is no need for the user to key in the different treatments, just pull down the correct one from the drop-down menu beside each tooth position tab.

4.1.2.8 Medical Records



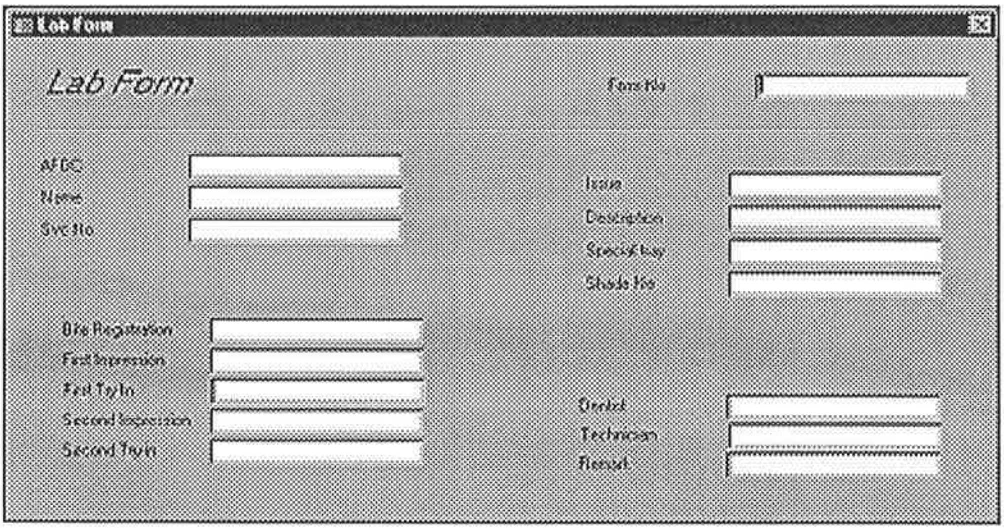
The Medical History/Records form is used to maintain any information that may be important **before** treatment is administered. In addition when the patient has any notable medical conditions e.g. heart disease or asthma, a red alert button will be displayed on the Clinical Record screen.

4.1.2.9 <u>Utilities</u>



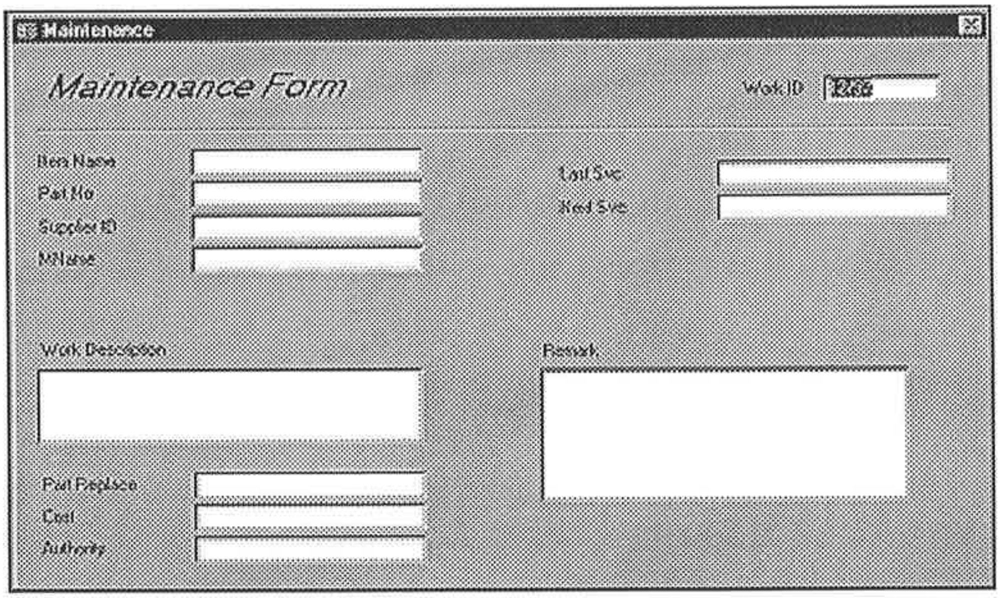
The Utilities form, as explained in Chapter 3.1 and Appendix 7, section 7.3, is used to navigate between the various utility forms available in OdontID Professional©.

4.1.2.10 Lab Form



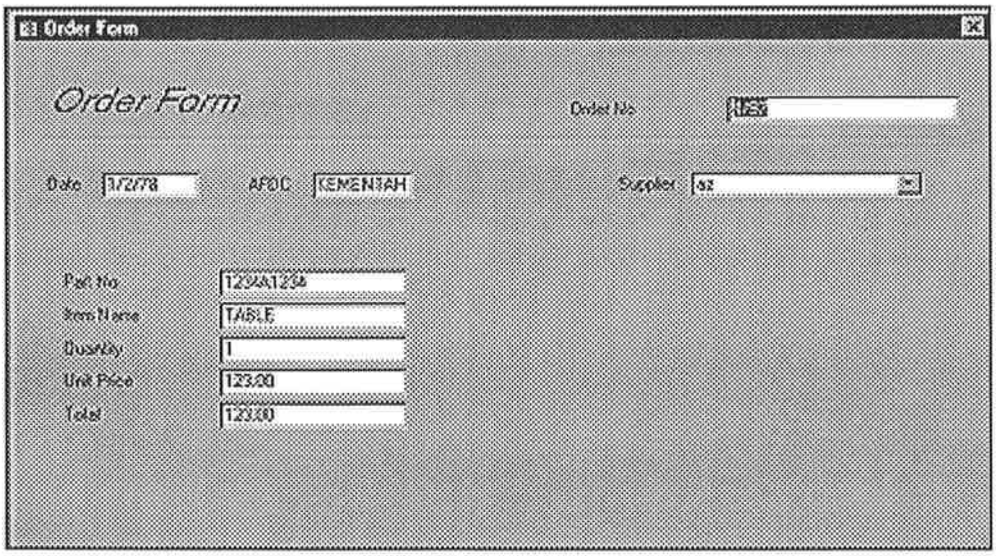
This form will not be used in this position in the final prototype, but is included here as it forms a part of the Utilities Form at the time of writing.

4.1.2.11 <u>Maintenance Form</u>



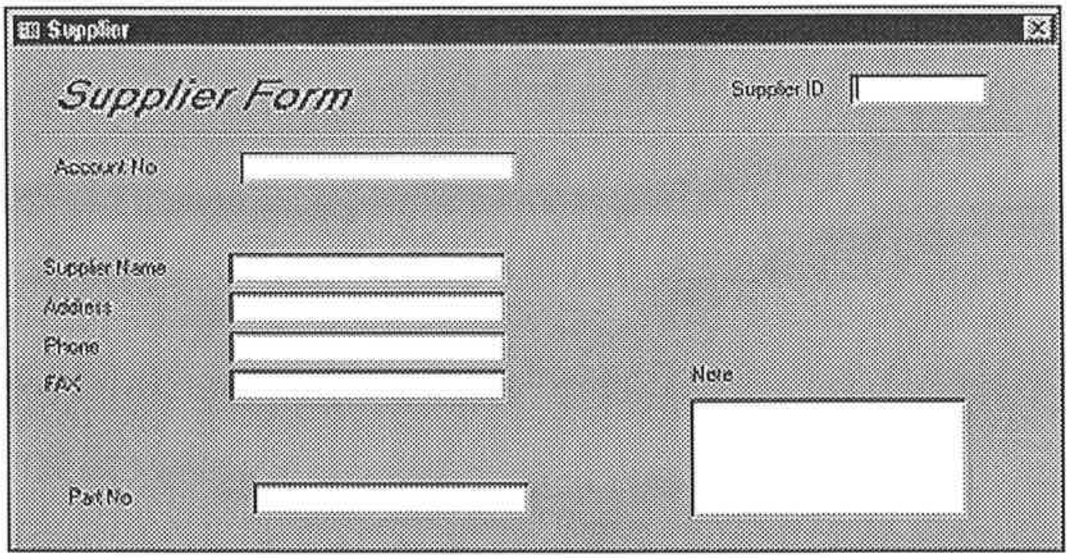
This form is used for physical environment maintenance requests.

4.1.2.12 <u>Order Form</u>



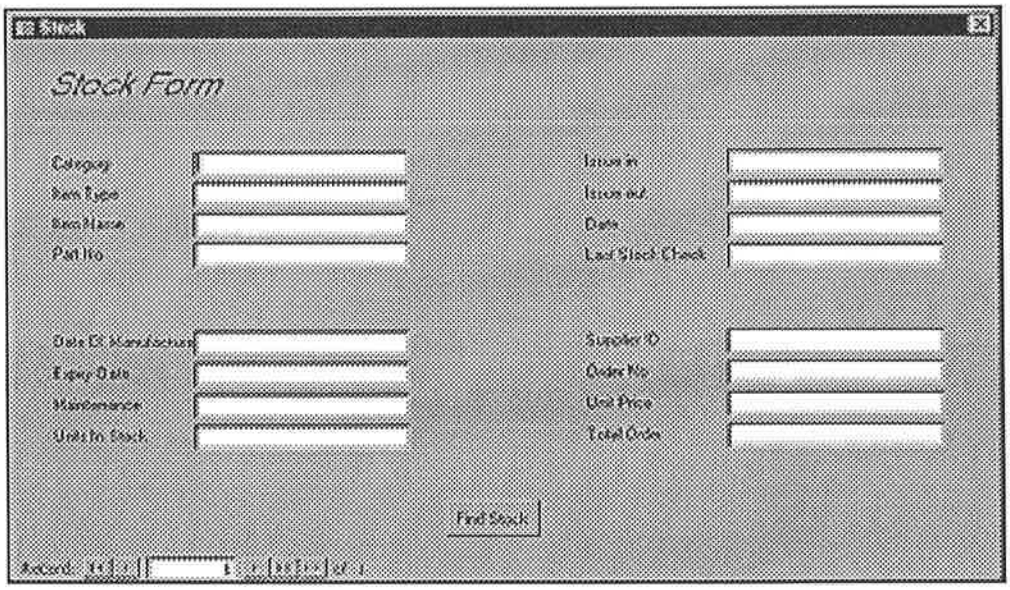
This form is used to order parts, equipment, or medical supplies.

4.1.2.13 <u>Suppliers</u>



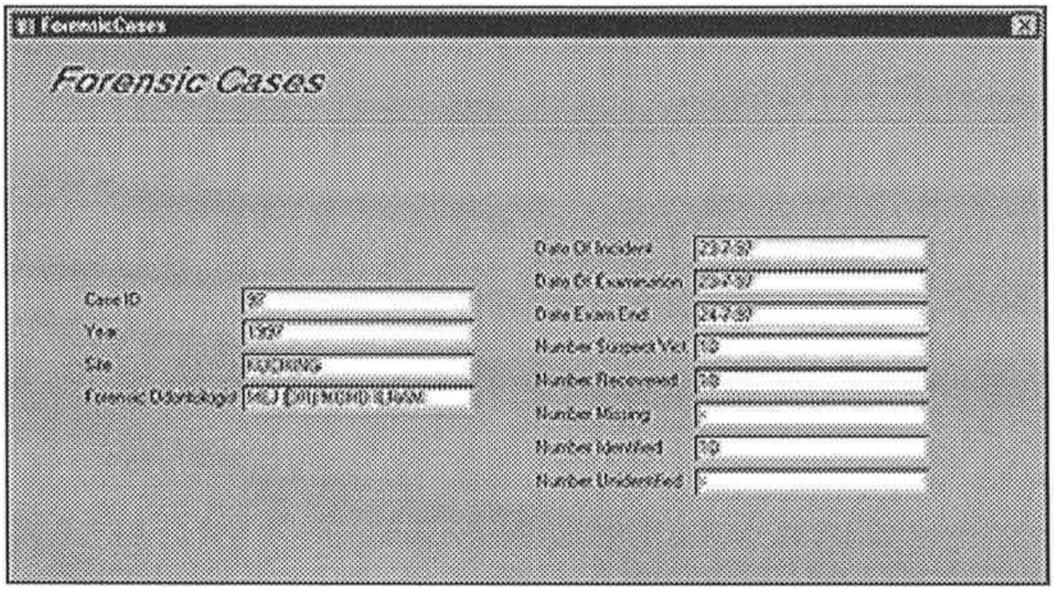
This form is used to track suppliers to stock and vice-versa.

4.1.2.14 <u>Stock</u>



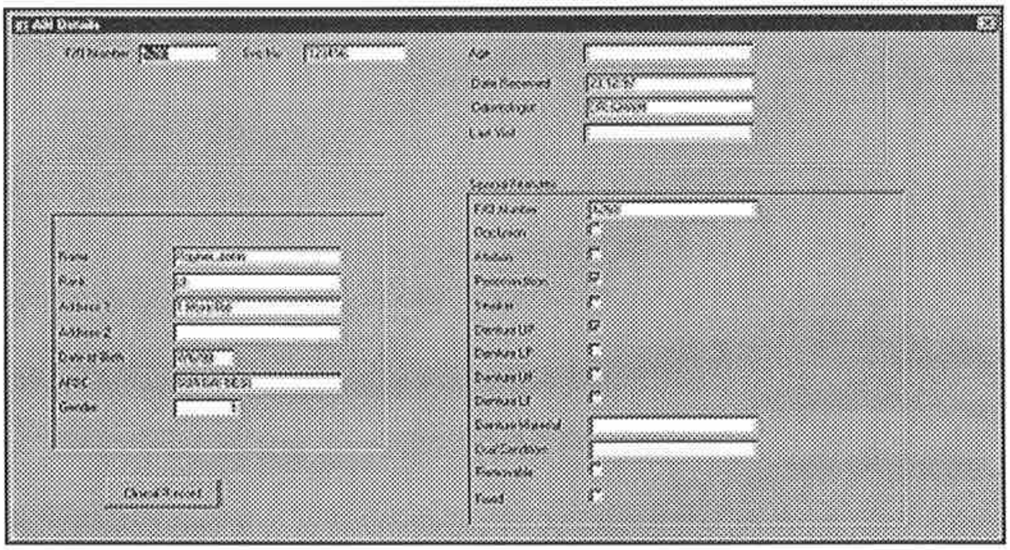
This form is used to track stock amounts. In the final prototype version, this form will automatically inform the user if a stock item has fallen below a certain critical level, and hence inform them that they should reorder.

4.1.2.15 <u>Forensic Case</u>



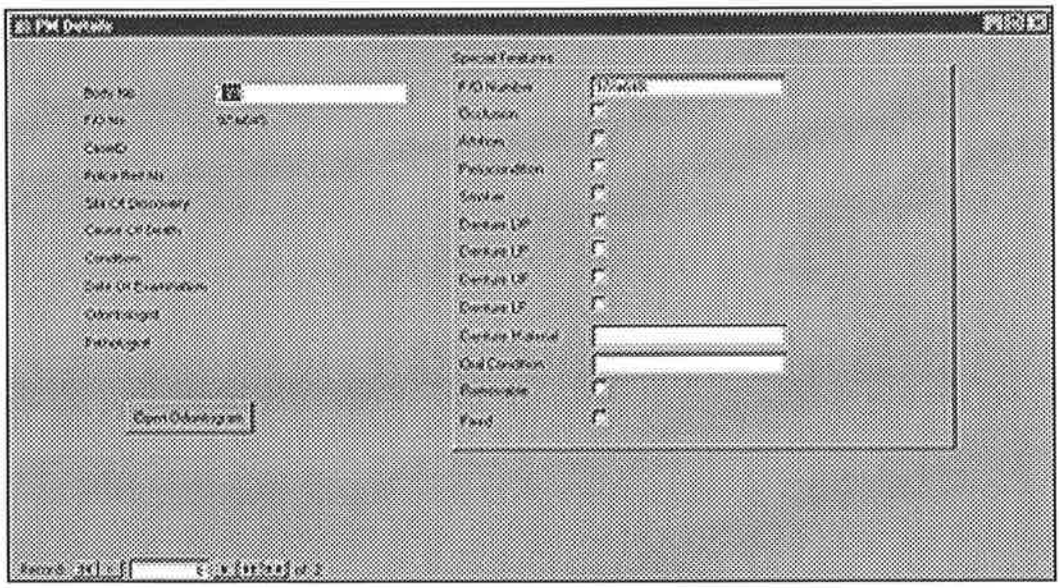
The Forensic Case form is used to maintain information about each forensic case and allows the user to enter incident details and names of forensic odontologists involved.

4.1.2.16 <u>Ante-mortem Details</u>



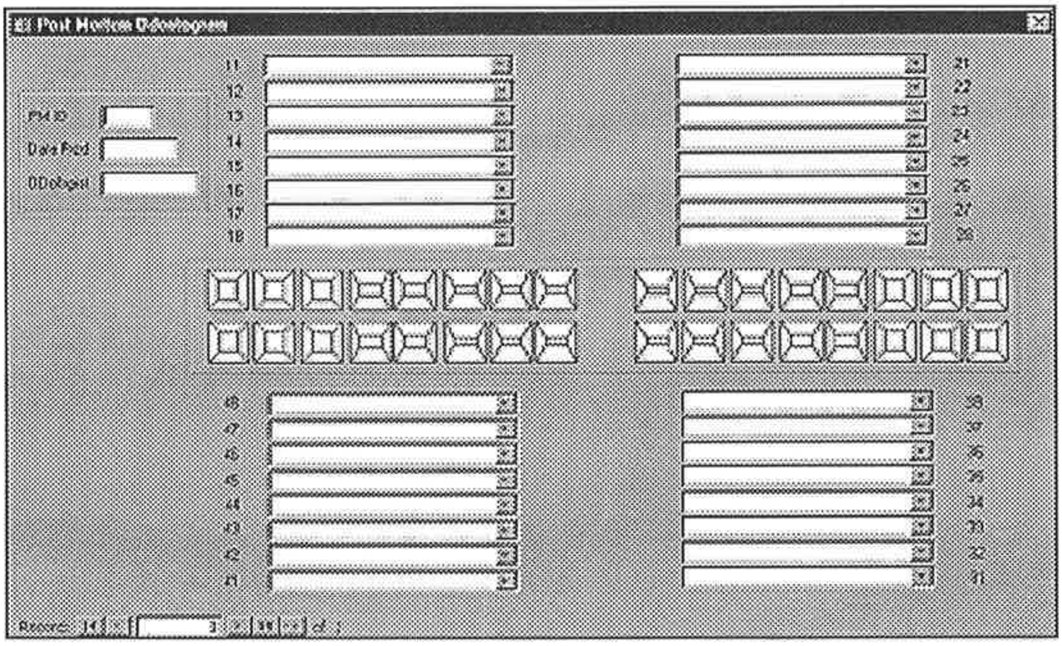
The Ante-mortem form maintains any information about each missing person. From this form, it is possible to view the details about the missing person's clinical records and look at their odontograms.

4.1.2.17 Post-mortem Details



The Post-mortem form is used to enter any information about each unknown person. This form also allows the user to enter the special features and to view the post-mortem odontogram.

4.1.2.18 <u>Post-mortem Odontogram</u>



The Post-mortem Odontogram form is used to highlight the state of an unknown remain's dentition. This odontogram is identical in feature with the ante-mortem odontogram.

4.2 MATCHING ALGORITHM

4.2.1 Relational Database Acquisition Engine (RDAE) Module

Before proceeding with an explanation of the function of the RDAE, it is important to be able to view the code first hand. This code has been written in Access Basic and will be included in the Appendix 7.5. There are three main functions:

1. CountDifferences – the actual search algorithm.
2. RecordCounter – used to set CountDifference's exit array.
3. FsmFieldParser – used to parse each field that does not have a match in both the ante-mortem and post-mortem tables.

The code used for OdontID Professional© currently contains known 'bugs' and is incomplete. It is to be used **only** for the prototype, as it only matches one post-mortem record to many ante-mortem records. To fulfil the release version requirements, the Matching Algorithm developer will need to re-organize the RDAE.

4.2.2 Description of the Code Used in OdontID Professional©

In true forensic situations the truth is not known and the comparison process is aimed at establishing an identification with a limited possibility of making a false positive identification. When the comparison process addresses differences between ante-mortem and post-mortem dental records it allows for emphasis to be placed on any incompatibilities and therefore reduces the risk of making a false positive match. The results of the matching process include apparent discrepancies and it is at this stage that an experienced forensic odontologist should interpret and explain the apparent discrepancies.

The aim of the OdontID Professional© matching process is to perform a generic search of the database for differences between ante-mortem and post-mortem forms. It will calculate the number of differences between ante-mortem and post-mortem dental records, which are based on the total number of 192 features (160 surfaces of 32 teeth in the permanent dentition), reports back total tooth differences and surface differences. This will provide a list of possible matches when multiple comparisons are made (e.g. mass disaster situations) stating different levels or numbers of discrepancies.

The match with the least number of differences is given first place in the list of possible matches and the matches with increasing numbers of differences are listed in order of reduced possibility of providing a positive match. It is important that any false negative matches can still be revealed through further assessment of the results of the matching process by a forensic odontologist, when all incompatible matches have been eliminated.

OdontID Professional© provides four types of comparison with three options to be selected: Total differences between ante-mortem and post-mortem dental records; quadrant differences between ante-mortem and post-mortem dental records; and special considerations, (selective features) from ante-mortem or post-mortem dental records to be compared. These options maintain the total differences encountered with each comparison made between the post-mortem and ante-mortem dental records. It also maintains a count of differences in each quadrant and any special considerations that may need to be taken into account. There are four types of comparison available for the matching process:

1. All ante-mortem to all post-mortem.
2. Single ante-mortem to all post-mortem.
3. Single post-mortem to all ante-mortem.

4. Single ante-mortem or post-mortem to single post-mortem or ante-mortem.

To date all existing forensic dental identification programmes only have the option for comparison between all quadrants in the entire record. OdontID Professional© has the capacity to perform selected options. This has advantages in the forensic field as the nature of post-mortem and ante-mortem material recovered varies widely and the method of comparison ideally should be adaptable to any situations that arise.

1. Option For Total Records Comparison. This option is important in routine forensic case work, where the state of human remains recovered is relatively intact, such as in cases of drowning or in situations where the most recent and accurate ante-mortem dental records were located.

2. Option For Quadrant Comparison. This allows for more limited and specific areas between records to be compared. This has application in situations whereby only fragmented and incomplete recovery of the dento-alveolar structures is made. For example in a situation where only the upper left maxilla and dentition was recovered, it is only appropriate to compare that data with the same area in the ante-mortem

record. This method avoids irrelevant discrepancies in the results and reflects a true comparison of the dental status of the human remains with the ante-mortem records in addition to any apparent discrepancies.

3. Option For Special Consideration. This allows the forensic odontologist to indicate specific features, treatment and restorations for comparison. This can be as specific as selecting one restoration only or combinations of specific features, which can be changed after each search to allow a narrower or wider selection of records to be considered. Where these options are included in the search, the comparisons are made only on those records which match the criteria specified, for example in those situations where a dentist has not recorded the previous status of the dentitions, and has only recorded the treatment which has been done at the time; or where limited material has been recovered from the seen; or if a forensic odontontologist wishes to search for a particular tooth or treatment.

Other matching algorithm features:

1. Declares record types (number of ante-mortem and post-mortem) that will be used for the comparison process.

2. Declares three types of differences:

   a. Total differences between ante-mortem and post-mortem dental records.

   b. Number of differences in each quadrant between ante-mortem and post-mortem dental records.

   c. Number of special considerations between ante-mortem and post-mortem dental records from the total number of differences.

3. Provides a printed list of possible identifications in descending order of possibility of providing a positive match.

4. Provides a print out record of the 5 combination odontograms for inclusion in formal reports:

   a. Ante-mortem odontogram with written record.

   b. Post-mortem odontogram with written record.

   c. Comparison of upper ante-mortem and post-mortem odontograms with written record.

d. Comparison of lower ante-mortem and post-mortem odontograms with written record.

e. Comparison of ante-mortem and post-mortem odontograms.

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

5.1 ANALYSIS OF THE ODONTID PROFESSIONAL© PROGRAMME

For the completion of this research, the method used to evaluate this programme will be discussed and the results of the evaluation are to be compared with those obtained from existing programmes. Computer systems are expensive and time consuming to design and operate. Distinct advantages for OdontID Professional© over conventional systems must therefore be shown in order to justify the high costs of computer equiptment, development of computer programmes and system maintenance.

OdontID Professional© should be analysed in order to assess it's value in terms of efficiency, ease of use for personnel and contribution to dental clinical management and forensic dental identification. This needs to be done in the working environment of the Armed Forces Dental Centre. The analysis of OdontID Professional© is yet to be completed as it requires a through evaluation of both the dental clinical management system and the forensic dental identification system. Two evaluation methods are proposed, a laboratory stage and a field test stage.

5.1.1 Laboratory Stage

The initial evaluation is designed to compare the efficiency of the new forensic dental identification system with existing programme, OdontID©. The OdontID Professional© programme has been used to compute dental records and complete a simulated forensic dental identification using available sets of ante-mortem and post-mortem dental records (previous cases) from the Forensic Odontology Unit, University of Adelaide as described in Section 5.5.2.

5.1.2 The Field Test Stage

In order to investigae the methods of computation and the accuracy of computing dental records within the Malaysian Armed Forces Dental Service, it is suggested that OdontID Professional© should be tested over a period of 3 months using dental records made during routine clinical procedures within the Armed Services.

One of the tests will assess the performance for clinical dental practice management and the other for forensic dental identification. However, since the Malaysian military personnel dental records are confidential and not available outside dental clinics in Malaysia, the programme can only be tested at the laboratory stage (internal evaluation). It is also more realistic to test the programme in the enviroment for which it was designed to be used and thus appropriate field testing is anticipated to be undertaken between August until October 1997, in Malaysia.

5.2 EVALUATION OF ODONTID PROFESSIONAL©

5.2.1 Analysis Of The Effectiveness Of The User Interface

A questionnaire has been created in order to generate some measure of response with respect to the user interface. The operators who will be engaging the OdontID Professional© programme are dental personnel within the Malaysian Armed Forces Dental Service. The operators will be asked to implement the programme by entering dental data and also execute a number of matching processes between ante-mortem and post-mortem dental records.

The questionnaire is designed to evaluate certain features of the user interface as described in Appendix 7.6, Table 7.7. The operators will also be asked to contribute their ideas about which aspects of the user interface may be improved.

5.2.2 Method To Analyse The Accuracy Of The OdontID Professional© Programme

In order to analyse the degree of accuracy of the OdontID Professional© programme, the routine computation of a set of clinical dental records and the matching process were tested for different values of accuracy and variation in order. A simulated data set of 10 ante-mortem and 10 post-mortem dental records were selected at random from previous cases made available through the Forensic Odontology Unit, University of Adelaide.

Records were numbered from 1 to 10 and A to J for post-mortem and ante-mortem dental records respectively. These were then compared using the programme. The matching process was analysed for three different types of comparison:

1. Comparison of all post-mortem records with all ante-mortem dental records.

2. Comparison of a single post-mortem record with all ante-mortem dental records.

3. Comparison of a single ante-mortem record with all post-mortem dental records.

The time required from the beginning of the initial comparison process through to when the results are displayed as the number of differences given between the matched ante-mortem and post-mortem records, will be recorded. Also the rank in the list of best matches will be compared. Tables 5.1, 5.2 and 5.3 will be shown including the results of computed dental record comparison by OdontID Professional©.

Table 5.1 List of best matches for the comparison of 10 post-mortem records with 1 ante-mortem record obtained from OdontID Professional©.

LIST BEST MATCH		NO IN THE LIST	NO OF DIFFERENCES	TOTAL TIME REQUIRED FOR COMPARISON
PM	AM	(10)	(192)	(min)
1	A	/10	/192	
2	A	/10	/192	
3	A	/10	/192	
4	A	/10	/192	
5	A	/10	/192	
6	A	/10	/192	
7	A	/10	/192	
8	A	/10	/192	
9	A	/10	/192	
10	A	/10	/192	

Table 5.2 List of best matches for the comparison of 1 post-mortem record with 10 ante-mortem records obtained from OdontID Professional©.

LIST BEST MATCH		NO IN THE LIST	NO OF DIFFERENCES	TOTAL TIME REQUIRED FOR COMPARISON
PM	AM	(10)	(192)	(min)
1	A	1	/192	
1	B	1	/192	
1	C	1	/192	
1	D	1	/192	
1	E	1	/192	
1	F	1	/192	
1	G	1	/192	
1	H	1	/192	
1	I	1	/192	
1	J	1	/192	

Table 5.3 List of best matches for the comparison of 10 post-mortem with 10 ante-mortem records obtained from OdontID Professional©.

	NUMBER OF DIFFERENCES (192)									
AM / PM	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

5.3 PROPOSALS FOR ASSESSMENT OF ODONTID PROFESSIONAL© PROGRAMME

It is anticipated that the results obtained from the OdontID Professional© programme in Tables 5.1, 5.2 and 5.3 will reveal that the accuracy of OdontID Professional© mainly depends on four factors.

1. The accuracy of the searching algorithm being used.

2. The accuracy of text retrieval data being stored and used.

3. The state in which the victim's remains were discovered e.g. incinerated, decomposed, fragmented or mutilated.

4. The degree of completeness of the ante-mortem dental data retrieved.

The programme will be used by the Malaysian Armed Forces Dental Service as well as the Forensic Odontology Unit, University of Adelaide for comparison of ante-mortem and post-mortem dental records in routine case work and mass disaster situations.

5.4 COMPARISON WITH THE ODONTID© PROGRAMME

In order to check the external accuracy and validity of this system, the results derived from the OdontID Professional© programme must be compared with the results derived from a known baseline system in this case the OdontID Programme©. The same records used in exercise 5.2 will be compared using the OdontID© programme following the same method, the results are as shown in Tables 3.2, 3.3, and 3.4.

For a further comparison exercise, the known set of ante-mortem and post-mortem dental records from previous cases will be compared using both OdontID Professional and the OdontID programme (single ante-mortem with single post-mortem dental record). Table 5.4 will show the results for both programmes.

The results shown in Tables 5.4 will indicate the time required for the comparison process and the best matches with respect to the least number of differences for both OdontID Professional© and the OdontID© programme. The minimum and maximum number of differences between these two programmes are to be shown in Table 5.5.

Table 5.4 Comparison of known sets of ante-mortem and post-mortem dental records using both OdontID Professional© and OdontID© programmes.

RECORDS		RANK	TIME REQUIRE (min)		NUMBER OF DIFFERENCES (192)	
AM	PM	(1/1)	OdontID	OdontID Pro	OdontID	OdontID Pro
A	1	(1/1)	2.5		0	
B	2	(1/1)	2.5		16	
C	3	(1/1)	3		83	
D	4	(1/1)	3		4	
E	5	(1/1)	3		55	
F	6	(1/1)	3		64	
G	7	(1/1)	3.5		32	
H	8	(1/1)	3		16	
I	9	(1/1)	2.5		8	
J	10	(1/1)	3.5		0	

Table 5.5 Comparison of the number of differences between OdontID Professional© and OdontID© programmes.

	Number of Differences					
	OdontID Programme			OdontID Professional		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
Minimum						
Maximum						

5.5 FUTURE APPLICATIONS WITHIN THE MALAYSIAN ARMED FORCES DENTAL SERVICES

It has been realised that initially the introduction of a new dental database system will require a considerable effort is likely to produce some turmoil temporarily. The capacity of computers to store and retrieve data and to rapidly perform calculations and logical operations has proved a powerful tool for use in dental administration, clinical applications, dental records systems, dental research and forensic dental identification. With the increase in the number of patients and staff in modern practice, the task of administering dental centres has become more complex and greater demands are placed upon clinical and clerical sections.

Furthermore, the introduction of multiple types of procedures and the nature of military service means that the task of maintaining accurate and up-to-date dental records becomes more difficult. It is anticipated that if a computerised dental record database system is used and the maintenance of dental records is by computer operation, accurate ante-mortem dental data can be made available. This goal will also be assisted by a further understanding or appreciation of the importance of accurate ante-mortem dental data within the Malaysian Armed Forces Dental Services.

A greater awareness within the dental community would emphasise the need for the provision of accurate ante-mortem dental data when required for civilian identification purposes. A mechanism built into the programme which will prevent the access of confidential military information when the dental identification system is needed for Disaster Victim Identification.

5.5.1 Compilation Of The Malaysian Armed Forces Dental Database System

Information regarding the current status of the Malaysian Armed Forces dental records can be found in AFMATI (1976)[119]. This provides a picture of the present coverage of clinical dental records of Malaysian military personnel (Appendix 7.2, Figures 7.19, 7.20 and 7.21). Sufficient and uniform dental data is needed for the forensic dental identification process. Due to different dental education backgrounds and several other factors, the requirements for uniform dental records are almost impossible to achieve under the current system. Hopefully with the use of a computerised dental database system, this problem can be resolved.

OdontID Professional© can be used as a reference base for future compilations of dental records so that the integration of dental records into a uniform system can be achieved. The test described in section 5.4 indicates that the OdontID Professional© programme provides the best method and solution for the computerisation of the Malaysian Armed Forces Dental Services.

The use of the OdontID Professional© programme is recommended with a network facility for the compilation of a dental database and to deal with the management and administration requirements within the Malaysian Armed Forces Dental Services. The management requirements can be roughly classified into four areas: coordination; centralisation; decentralisation; and productivity enhancement. Coordination includes the synchronisation of activities, to bring together dispersed elements into a unified action which is important in a military organisation. Without coordination any actions can precipitate catastrophic failure as opposed to tremendous success. Since direct access to a computer will become available, dental centre monitoring systems are feasible and greater application of such information or instruction can be expected in future.

Another aspect of the OdontID Professional© network system is the ability to centralise control. This facility can be used to provide a central computer with on line capability to access and distribute necessary information and resources to where it is needed in a short period of time. OdontID Professional© can be used to interconnect all dental centres and computers together into a simple system by providing a uniform interface. This can be done without losing control of the corporation information. Productivity would also increase with such a system as more information would be dispersed and integrated in an efficient form. Therefore the sharing of such a resource between dental centres would be of great benefit to the Malaysian Armed Forces Dental Services.

5.5.2 The Proposed Uses Of OdontID Professional© For Forensic Dental Identification Within The Malaysian Armed Forces

Forensic dental identification is concerned with the following procedures: collection of ante-mortem dental records, post-mortem examination, and comparison of ante-mortem records with post-mortem findings. The application of computers in forensic dentistry does not aim to displace the forensic odontologists from their professional role but it is designed to reinforce their ability to carry out dental identification by improving the quality and quantity of information made available to them and also facilitate their efforts within a minimum time span.

The advance of computer network systems has renewed interest in international communication in regards to forensic dental identification due to the potential of efforts to share dental information through the network database system in a very short time. The OdontID Professional© programme used in conjunction with a network system offers computer assisted dental identification which is use friendly and immeasurably more accurate and efficient than the manually sorted methods of the past.

Continuous efforts are needed in the collection of dental records which comprise military personnel as well as the civilian Malaysian population in general, so that an adequate data base can be created in the region. Sufficiently accurate and uniformly standardised dental clinical records can be used together with a forensic dental identification system to achieve a precise dental identification process. The forensic dental identification procedure integrated with the use of OdontID Professional© may facilitate the identification process making it more efficient within the Malaysian Armed Forces, the Malaysian population and internationally.

5.6 REVIEW AND PLANS FOR ANY FUTURE MODIFICATIONS AND REWRITING WHICH MAY BE NECESSARY

5.6.1 The Search Function

The performance of the search function is fundamental to the efficiency of OdontID Professional©. Results of the laboratory and the field test will be interpreted with particular emphasis on accuracy and sensitivity of the special features functions. If necessary, modifications will be made.

5.6.2 Other Applications

Results of the effectiveness of the user interface will be interpreted. It may appear necessary to make modifications or adjustments following receipt of the results which will include any changes recommended by the personnel involved, and problems encountered.

CHAPTER 6

CONCLUSIONS

6. CONCLUSIONS

The present study achieved the initial objective which was to review the literature concerning the use of computers in dental clinical management systems and the application of computers in forensic dental identification. The next objective addressed the approach required for computers to be integrated into dental clinical management within the Malaysian Armed Forces, in combination with a computer assisted forensic dental identification system.

A review of the current literature exposed the main differences between the special features of computer software packages for both dental clinical management systems and forensic dental identification systems. The development of these two type of systems has been specifically designed to the requirement of each system alone and to date there has been no single computer software package which integrates all the requirement of these two system in such a way that they operate separately but compliment each other. Therefore, it was concluded that in order to meet the requirements of adopting a computer software package for use within the Malaysian Armed Forces which also could a forensic dental identification system, it was necessary write a new programme.

The OdontID Professional© programme was developed for the purpose of computerisation of Malaysian Armed Forces dental records and forensic dental identifications. Conclusions drawn from observations made during the development of the programme have led to the following proposals:

1. It is suggested that all Malaysian Armed Forces dental data is to be recorded in a format or manner which will facilitate future computation, so that when required, existing data can be easily and readily accessed.

2. If sufficient ante-mortem dental records are to be maintained, the dental records must be compiled as a computerised dental database system.

3. It has been shown that in the future, a proposed dental database system can be used to aid dental comparison by use of computers in the role of forensic dental identification in routine cases and especially in cases of mass disasters.

4. In addition to computerised Malaysian Armed Forces dental records, the existing dental records can also be maintained as composite records.

5. Following the application of the OdontID Professional© programme, a dental database system can be established and subsequently used to facilitate the forensic dental identification process within the Malaysian Armed Forces and civilian population.

6. In addition to the use of computers for dental identification, the dental database system is also needed for the efficient maintenance of adequate and sufficient ante-mortem and post-mortem dental records. Therefore, a comprehensive and suitable computer system, which is able to fulfil both requirements is necessary.

7. In future, in order to verify the computed dental records and forensic dental identification system, an independent network system should be established throughout Malaysia with a main station located in Kuala Lumpur.

8. The Malaysian Armed Forces Dental Service is currently making preparations for integrating information technology into the service. Computers are to be used for departmental, clerical and clinical purposes. When the computer system has been in installed and implemented, it is desirable that it

should have features which are adaptable to future advances in information technology.

9. OdontID Professional© programme has been designed to be compatible with current technology. In addition it has the capacity to expand and adapt to current advances in information technology such as digital image transmission and storage.

CHAPTER 7

APPENDICES

7.1 DENTAL NOTATION SYSTEMS

The standards of dental records vary and the interpretation of detailed and complex information requires a thorough knowledge of the various tooth notations or abbreviations used[121]. Frykholm and Lysell[106] divided dental notation systems into two categories: those having a similar notation for the teeth in each segment and, those having a different notation.

7.1.1 Systems Having A Similar Notation In Each Segment

System 1 **The Zsigmondy System**

An Austrian dentist, Adolph Zsigmondy[107] in 1861 described the first and oldest known method of recording the positions of the teeth in the mouth. This system relies on a grid placed around the tooth to indicate its position in the mouth, either upper or lower and left or right. The permanent dentition is assigned with Arabic numerals, whilst the primary dentition is given Roman numerals. All teeth from the central incisor to the last molar of each segment are given the numbers **1** to **8** in the permanent dentition or **I** to **V** in the primary dentition (Figure 7.1). The segments are shown by a vertical line drawn between the central incisor and a horizontal line separating the upper and lower teeth (the symbols ┘, └ , ┐ and ┌ for patient's upper right, upper left, lower right and lower left quadrants respectively). In the permanent dentition the upper right first molar becomes 6┘ and lower left second molar then becomes ┌7 . This system is widely used in Europe, North and South America, Japan and Australia. The system has disadvantages in typing or print especially in order to place a quadrant symbol.

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

Lower right permanent first molar is 6┐.

Primary	V	IV	III	II	I	I	II	III	IV	V
Teeth	V	IV	III	II	I	I	II	III	IV	V

Lower right deciduous first molar is IV┐.

Figure 7.1 The Zsigmondy System for permanent and primary dentitions.

Variation to the Zsigmondy System For Primary dentition

The primary dentition are assigned the letters from **'a'** to **'e'** instead of Roman numerals I to V[106]. Sometime the latter **'D'**, **'d'** or **'m'** are placed immediately after or before the number of the tooth (Figure 7.2) These variations are used throughout the world especially in English-speaking countries.

Primary	e	d	c	b	a	a	b	c	d	e
Teeth	e	d	c	b	a	a	b	c	d	e

Lower left deciduous first molar is d .

Primary	5d	4d	3d	2d	1d	1d	2d	3d	4d	5d
Teeth	5d	4d	3d	2d	1d	1d	2d	3d	4d	5d

Lower left deciduous first molar is 4d.

Primary	5D	4D	3D	2D	1D	1D	2D	3D	4D	5D
Teeth	5D	4D	3D	2D	1D	1D	2D	3D	4D	5D

Lower left deciduous first molar is 4D.

Primary	5m	4m	3m	2m	1m	1m	2m	3m	4m	5m
Teeth	5m	4m	3m	2m	1m	1m	2m	3m	4m	5m

Lower left deciduous first molar is 4m.

Figure 7.2 Variation in tooth notation for primary dentition in Zsigmondy System.

System 2 <u>Zsigmondy/Palmer System</u>

In 1870, Corydon Palmer[117], an American dentist, introduced the Zsigmondy system at the meeting of the American Dental Association (ADA) in Nashville. He altered the use of roman numerals for the primary dentition to upper-case letter from **A** to **E**. This Zsigmondy/Palmer System has been widely used internationally (Figure 7.3).

Primary	E	D	F	B	A	A	B	C	D	E
Teeth	E	D	F	B	A	A	B	C	D	E

Lower right deciduous first molar is D⌉.

Figure 7.3 The Palmer System for primary dentition.

System 3 <u>Opposite Order To The Zsigmondy/Palmer System</u>

This system employs numerals **'1'** to **'8'** for enumerating the permanent dentition and **'A'** to **'E'** for the primary dentition but in the opposite order to the Zsigmondy/Palmer System[106]. It begins with number 1 for the third permanent molar and the letter 'A' for the second primary molar and ends with '8' and 'E' respectively for the central incisor (Figure 7.4).

Permanent	1	2	3	4	5	6	7	8	|	8	7	6	5	4	3	2	1
Teeth	1	2	3	4	5	6	7	8	|	8	7	6	5	4	3	2	1

Lower right first molar is 3⌉.

Primary	A	B	C	D	E |	E	D	C	B	A
Teeth	A	B	C	D	E |	E	D	C	B	A

Lower right deciduous first molar is B⌉.

Figure 7.4 The opposite system to the Zsigmondy/Palmer System for permanent and primary dentitions.

System 4 <u>The Holland System</u>

This system employs the same angle signs as in the Zsigmondy/Palmer System but no numerals are used, with the teeth being designated according to their respective Latin names by using the initial, from central incisor to third molar[106]. The incisors **(I)**, canines **(C)**, premolars **(P)** and molars **(M)** are indicated in the following way:

$$\mathbf{I_1,\ \ I_2,\ \ C,\ \ P_1,\ \ P_2,\ \ M_1,\ \ M_2,\ \ M_3}$$

The permanent dentition is in the upper case and primary in the lower case supplemented with the letter **'d'** (deciduous) placed before the latter symbol (Figure 7.5). It is also similar for notation of mammalian dentitions in comparative anatomy[221]. This system is employed mainly in Holland.

Permanent Teeth

$$\begin{array}{cccccccc|cccccccc}
M_3 & M_2 & M_1 & P_2 & P_1 & C & I_2 & I_1 & I_1 & I_2 & C & P_1 & P_2 & M_1 & M_2 & M_3 \\
\hline
M_3 & M_2 & M_1 & P_2 & P_1 & C & I_2 & I_1 & I_1 & I_2 & C & P_1 & P_2 & M_1 & M_2 & M_3
\end{array}$$

Lower right first molar is $\overline{M_1}\rvert$.

Primary Teeth

$$\begin{array}{ccccc|ccccc}
dm_2 & dm_1 & dc & di_2 & di_1 & di_1 & di_2 & dc & dm_1 & dm_2 \\
\hline
dm_2 & dm_1 & dc & di_2 & di_1 & di_1 & di_2 & dc & dm_1 & dm_2
\end{array}$$

Lower right deciduous first molar is $\overline{dm_1}\rvert$.

Figure 7.5 The used of initial letters derived from their Latin names to designate the permanent and primary dentitions in the Holland System.

System 5 <u>Haderup System</u>

Haderup in 1891 invented a system which made use of plus **(+)** and minus **(-)** signs to indicate the arch and also the quadrant[107,112]. This system however, maintains the anatomical classification of permanent and primary dentitions as introduced by Zsigmondy. A plus (+) sign is used to indicate maxillary teeth and a minus (-) sign to indicate mandibular teeth. This sign is placed before or after a maxillary or mandibular tooth to indicate the left or right quadrants. A vertical line drawn between the central incisors represents the median plane and a horizontal line as the occlusal plane. Initially the letter **'l'** (Lactous) was placed before the numerals in primary dentition, but after a few years this was substituted by the letter **'O'**.

The upper right first molar designated 6 (Zsigmondy System) then becomes **6+** and lower left second premolar designated 5 (Zsigmondy system) then becomes **-5** (Figure 7.6). This system has been used in Scandinavia (Sweden, Denmark, Norway, Finland, and Iceland) and is also found in Germany, Italy, Switzerland, Yugoslavia, Poland and Czechoslovakia. However, it is not suitable for computer processing.

Permanent	8+	7+	6+	5+	4+	3+	2+	1+	+1	+2	+3	+4	+5	+6	+7	+8
Teeth	8-	7-	6-	5-	4-	3-	2-	1-	-1	-2	-3	-4	-5	-6	-7	-8

Lower right first molar is 6-.

Primary	05+	04+	03+	02+	01+	+01	+02	+03	+04	+05
Teeth	05-	04-	03-	02-	01-	-01	-02	-03	-04	-05

Lower right deciduous first molar is 04-.

Primary	50+	40+	30+	20+	10+	+01	+02	+03	+04	+05
Teeth	50-	40-	30-	20-	10-	-01	-02	-03	-04	-05

Lower right deciduous first molar is 40-.

Primary	V+	IV+	III+	II+	I+	+I	+II	+III	+IV	+V
Teeth	V-	IV-	III-	II-	I-	-I	-II	-III	-IV	-V

Lower right deciduous first molar is IV-.

Figure 7.6 The Haderup System for permanent and primary dentitions.

System 6 Modification of The Holland System

This system uses the same system notation as system 3, i.e. their respective Latin names but without use of the same angle sign[106]. The upper jaw is indicated by the letter **'s'** (superior) or the lower jaw by **'i'** (inferior), and followed by the letter **'d'** (dexter/right) or the letter **'s'** (sinister/left) in subscription and both are placed immediately after the index numeral. The small letters are used for the primary teeth and the method is the same as permanent teeth, i.e., i_1, i_2, c, m_1 and m_2. This system is used in Holland and some other countries (Figure 7.7).

M_{3sd} M_{2sd} M_{1sd} P_{2sd} P_{1sd} C_{sd} I_{2sd} I_{1sd} I_{1ss} I_{2ss} C_{ss} P_{1ss} P_{2ss} M_{1ss} M_{2ss} M_{3ss}
M_{3id} M_{2id} M_{1id} P_{2id} P_{1id} C_{id} I_{2id} I_{1id} I_{1is} I_{2is} C_{is} P_{1is} P_{2is} M_{1is} M_{2is} M_{3is}

Lower right first permanent molar is M_{1id}.

m_{2sd}	m_{1sd}	c_{sd}	I_{2sd}	I_{1sd}	I_{1ss}	I_{2ss}	c_{ss}	m_{1ss}	m_{2ss}
m_{2id}	m_{1id}	c_{id}	i_{2id}	i_{1id}	i_{1is}	i_{2is}	c_{is}	m_{1is}	m_{2is}

Lower right deciduous first molar is m_{1id}.

Figure 7.7 Modifications to the Holland System by using the letters 's', 'i', 'd' and 's' to indicate the arch and the quadrant of the permanent and deciduous dentitions.

System 7 **The South African System**

This system is similar to system 3 which uses the same letter and index numeration for the teeth, however, the segment is indicated by the position of the index in relation to the alphabetical letter of the tooth[106]. The index is placed before or after the alphabetical symbol for the right or left segment, and in superscription or subscription to indicate the upper or lower dentition.

Thus ${}^{1}M$ is the upper right first molar, M^1 the upper left first molar, ${}_{2}M$ for lower right second molar, and M_2 for the lower left second molar (Figure 7.8). This system is used in South Africa.

Permanent	${}^{3}M$	${}^{2}M$	${}^{1}M$	${}^{2}P$	${}^{1}P$	C	${}^{2}I$	${}^{1}I$	I^{1}	I^{2}	C	P^{1}	P^{2}	M^{1}	M^{2}	M^{3}
Teeth	${}_{3}M$	${}_{2}M$	${}_{1}M$	${}_{2}P$	${}_{1}P$	C	${}_{2}I$	${}_{1}I$	I_{1}	I_{2}	C	P_{1}	P_{2}	M_{1}	M_{2}	M_{3}

Lower right first molar is ${}_{1}M$.

Figure 7.8 The South African System which uses indices to indicate the segment for permanent dentition.

System 8 **The French and Romanian System**

This system uses the same designation as the Zsigmondy system for permanent dentition, however, alphabetical letters are used to indicate the segment[106]. The teeth in the upper right jaw are indicated by **'D'** (droite/right), upper left by **'G'** (gauche/left), and the teeth in the lower jaw are indicated by a lower case **'d'** or **'g'** which is placed immediately in front of the number of the tooth. Primary teeth are indicated by substituting Roman numerals with the Arabic numerals from **1** to **5**. This system is only used in France and Romania (Figure 7.9).

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

Lower right first permanent molar is $\overline{\text{d6}}|$.

Primary	D5	D4	D3	D2	D1	G1	G2	G3	G4	G5
Teeth	d5	d4	d3	d2	d1	g1	g2	g3	g4	g5

Lower right deciduous first molar is d4.

Figure 7.9 The French and Romanian System which uses indices to indicate the segment for permanent and primary dentitions.

System 9 The FDI Two-Digit System

The Theilman notation or FDI Two-Digit System was introduced at the fifty-eigth annual meeting of the FDI in 1970[106,112,115,126]. This system maintains the same system of numbering permanent and primary dentitions as Zsigmondy/Palmer System, i.e. **'1'** to **'8'**. In addition, a separate number has been given to each quadrant from **'1'** to **'4'** for the permanent dentition and **'5'** to **'8'** for the primary dentition, which represents a clockwise rotation of numbering quadrants.

The upper right quadrant is numbered 1 or 5, upper left quadrant is numbered 2 or 6, lower left quadrant is numbered 3 or 7 and lower right quadrant is numbered 4 or 8 for permanent and deciduous dentitions respectively (Figure 7.10). The upper right first molar in permanent dentition designated 6 (Zsigmondy/Palmer System) then becomes 16 (read as one-six) and lower left second miolar in primary dentition designated E (Zsigmondy/Palmer System) then becomes 75 (read as seven-five).

	Quadrant No. 1								Quadrant No. 2							
Permanent	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
Teeth	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
	Quadrant No. 4								Quadrant No. 3							

Lower right permanent first molar is 46 (read as four-six).

	Quadrant No. 5					Quadrant No. 6				
Primary	55	54	53	52	51	61	62	63	64	65
Teeth	85	84	83	82	81	71	72	73	74	75
	Quadrant No. 8					Quadrant No. 7				

Lower right deciduous first molar is 84 (read as eight-four).

Figure 7.10 The FDI Two-Digit System for permanent and primary dentitions.

The FDI Two-Digit System is in widespread use by all dental schools in Scandinavia, South Africa, Zimbabwe, South East Asia, New Zealand and Australia. It has been officially adopted by the World Health Organisation (WHO) for use in their epidemiological surveys and publications, the International Police (INTERPOL) for international recording in relation to identification, the International Organisation for Standardisation (ISO), the International Association for Dental Research (IADR) and subsequently by the American Dental Association (ADA)[112].

7.1.2 Systems With A Different Notation In Each Segment

Apart from those systems already mentioned, in some countries particularly in the USA, several systems employing different notations for teeth in the different segments are in use. The most common of these systems are the Universal System, the Army System, the Navy System, and the Bosworth System.

System 10 **Cunningham's "Universal" System**

Cunningham's "Universal" System which was introduced in 1883[106,112], gives each tooth a number starting with the upper right third molar as No.**1**. Numbering follows sequentially in a clockwise direction around the upper arch, then around the lower arch ending with the lower right third molar as No. **32**. The primary dentition follows the same as permanent dentition but is indicated by alphabetical letters from **'A'** to **'T'** or sometimes by placing the letter **'D'** before the numerals **1** to **20** (Figure 7.11).

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

Lower right first molar is 30.

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

Lower right deciduous first molar is S.

Primary	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Teeth	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11

Lower right deciduous first molar is D19.

Figure 7.11 The Cunningham "Universal" System for permanent and primary dentitions.

System 11 <u>**Goodman's "Universal" System**</u>

This system also underwent a number of modifications in the USA. Goodman[114] in 1967 proposed the use of a number to correlate the primary dentition to the permanent dentition. Starting with No. **41** for the upper right molar, following a clockwise rotation around the upper arch, then around the lower arch ending with lower right molar as No. **60** (Figure 7.12).

Primary	41	42	43	44	45	46	47	48	49	50
Teeth	60	59	58	57	56	55	54	53	52	51

Lower right deciduous first molar is 59.

Figure 7.12 The Universal System for primary dentition by Goodman.

System 12 **<u>The United States Army System (Combination part "Universal" and part Zsigmondy-Palmer)</u>**

This system employs numericals **'1'** to **'16'** for enumerating the permanent dentition and letters **'A'** to **'J'** for the primary dentition[112]. In the permanent dentition it begins with number 1 for the upper central incisor (Zsigmondy-Palmer System) and number 9 for the lower central incisor (The upper left quadrant in Cunningham's Universal System) and letters **'A'** and **'F'** respectively for the primary dentition as shown in Figure 7.13.

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

Lower right first molar is 14.

Primary	E	D	C	B	A	A	B	C	D	E
Teeth	J	I	H	G	F	F	G	H	I	J

Lower right deciduous first molar is I.

Figure 7.13 The US Army System which uses indices to indicate the segment for permanent dentition.

System 13 The United States Navy version of the "Universal" System

This system is the most common modification of Cunningham's Universal system[106,107,112]. Here the sequence of numbers are reversed for the mandibular dentition (Figure 7.14). i.e. progress from lower right third molar to lower left third molar.

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

Lower right first molar is 19.

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

Lower right deciduous first molar is L.

Primary	I	II	III	IV	V	VI	VII	VIII	IX	X
Teeth	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX

Lower right first molar is XIII.

Figure 7.14 The United States Navy version of the "Universal" System for permanent and primary dentitions.

System 14 The Cincinnati System

This system is the mirror image of the Navy system, where both upper and lower jaws are numbered from left to right[106]. The primary teeth are indicated by the letter **'D'** placed before the numbers of the corresponding primary teeth (Figure 7.15). This system is employed only in Cincinnati, USA.

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

Lower right first molar is 30.

Primary	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1
Teeth	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11

Lower right deciduous first molar is D19.

Figure 7.15 The Cincinatti System which uses indices to indicate the segment for permanent and primary dentitions.

System 15 The Bosworth System

This system uses numbers and alphabetic letters to represent upper and lower permanent dentitions respectively from number 1 to 8 for the upper teeth and the letters **'A'** to **'H'** for the lower[106,107,112]. The primary teeth are indicated by placing the letter **'D'** before the numbers or letters for the corresponding tooth (Figure 7.16).

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

Lower right first molar is F.

Primary	D5	D4	D3	D2	D1	D1	D2	D3	D4	D5
Teeth	DE	DD	DC	DB	DA	DA	DB	DC	DD	DE

Lower right deciduous first molar is DD.

Figure 7.16 The Bosworth System which uses numbers and alphabetic letters to indicate the segments of permanent and primary dentitions.

System 16 <u>Modification of the "Universal" System in Australia</u>

This is a system which is the exact mirror image of the Cunningham 'Universal System'[(222)]. This system has only been reported in one case from South Australia, in the 1970's (Figure 7.17).

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

Lower right first molar is 19.

Figure 7.17 A modification "Universal" System which is a mirror image to the Cunningham "Universal" System and used for the permanent dentition only.

7.1.3 Comparison Of Different Dental Notation Systems

To summarise the different systems and facilitate a comparison between them, a table is shown to indicate how each of the 14 systems registers: the upper and lower permanent dentition (Tables 7.1 and 7.2).

Table 7.1 Comparison between fourteen different systems of dental notation for upper permanent dentition.

UPPER QUADRANT																
System	Right								Left							
1	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
3	1	2	3	4	5	6	7	8	8	7	6	5	4	3	2	1
4	M_3	M_2	M_1	P_2	P_1	C	I_2	I_1	I_1	I_2	C	P_1	P_2	M_1	M_2	M_3
5	8+	7+	6+	5+	4+	3+	2+	1+	+1	+2	+3	+4	+5	+6	+7	+8
6	M_{3sd}	M_{2sd}	M_{1sd}	P_{2sd}	P_{1sd}	C_{sd}	I_{2sd}	I_{1sd}	I_{1ss}	I_{2ss}	C_{ss}	P_{1ss}	P_{2ss}	M_{1ss}	M_{2ss}	M_{3ss}
7	^3M	^2M	^1M	^2P	^1P	C	^2I	^1I	I^1	I^2	C	P^1	P^2	M^1	M^2	M^3
8	D8	D7	D6	D5	D4	D3	D2	D1	G1	G2	G3	G4	G5	G6	G7	G8
9	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
12	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
13	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
14	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
15	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
16	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Example: TheUpper right permanent second premolar is represented in system 1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, and16 respectively as follows: $\underline{5|}$, $\underline{4|}$, $\underline{P_2|}$, 5+, P_{2sd}, $\underline{^2P\,|}$, D5 , 15, 4, $\underline{5\,|}$, 4, 13, 5 and 13.

Table 7.2 Comparison between fourteen different system of dental notation for lower permanent dentition.

LOWER QUADRANT																
System	Right								Left							
1	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
3	1	2	3	4	5	6	7	8	8	7	6	5	4	3	2	1
4	M_3	M_2	M_1	P_2	P_1	C	I_2	I_1	I_1	I_2	C	P_1	P_2	M_1	M_2	M_3
5	8-	7-	6-	5-	4-	3-	2-	1-	-1	-2	-3	-4	-5	-6	-7	-8
6	M_{3id}	M_{2id}	M_{1id}	P_{2id}	P_{1id}	C_{id}	I_{2id}	I_{1id}	I_{1is}	I_{2is}	C_{is}	P_{1is}	P_{2is}	M_{1is}	M_{2is}	M_{3is}
7	${}_3M$	${}_2M$	${}_1M$	${}_2P$	${}_1P$	C	${}_2I$	${}_1I$	I_1	I_2	C	P_1	P_2	M_1	M_2	M_3
8	d8	d7	d6	d5	d4	d3	d2	d1	g1	g2	g3	g4	g5	g6	g7	g8
9	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
10	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
12	16	15	14	13	12	11	10	9	9	10	11	12	13	14	15	16
13	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
14	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
15	A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

Example: The Lower left permanent lateral incisor is represented in systems 1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, and16 as follows: $\lceil 2$, $\lceil 7$, $\lceil I_2$, -2, I_{2is}, $\lceil I_2$, g2 , 32, 23, $\lceil 10$, 26, 23, B and 26 for respectively.

7.1.4 Systems For Registration Of Tooth Surfaces

There are a number of different systems for the registration of tooth surfaces and the localisation of decay and fillings[106]. Some systems refer to different surfaces by using the first letter of the Latin name for the surface (Table 7.3). Others use numerals to refer to the different surfaces of the Latin names for the tooth surfaces and Black's classification to record the surfaces by using the Roman numerals I to V.

System A. This is the most common method to indicate the different surfaces[106].

Table 7.3 An alphabetical code used in Finland and Denmark.
Source: Frykholm and Lysell (1962)

Initial	Surfaces
m	mesial/medial
o	occlusal/central
d	distal
b	buccal/labial/facial
l	lingual
i	incisal
p	palatal

In recent years the letter **'V'** (vestibular) is used instead of **'b'** (buccal), **'f'** (facial) or **'l'** (labial) to avoid confusion between labial and lingual (l). In older systems in Germany, the letter **'c'** (central) is used more often than **'o'** (occlusal). However, the letter **'c'** may be interpreted as either occlusal or cervical.

In most countries, the letter **'l'** (lingual) is used to mean the surface of a tooth that faces the tongue and **'p'** (palatal) for the teeth of the upper jaw. However the letter 'l' can easily be confused with the numeral '1' in type. In the USA, Germany and Yugoslavia the letter **'li'** or **'la'** is sometimes used to indicate the lingual and labial surface of a tooth respectively.

System B. This system replaces the use of alphabetical code with a numerical code as shown in Tables 7.4 and 7.5[106]. This has been found in Denmark and Finland.

Table 7.4 A numerical code which has been used in Finland and Denmark.
Source: Frykholm and Lysell (1962)

Number	Surfaces
1	occlusal
2	mesial
3	facial
4	distal
5	lingual
6	cervical

Table 7.5 A numerical code which has been used in USA.
Source: Frykholm and Lysell (1962)

Number	Surfaces
1	mesial
2	distal
3	buccal
4	lingual
5	occlusal

System C. In this system the surfaces are recorded according to Black's classification (Table 7.6)[106]. This system has been used in the USA, the United Kingdom and a few other countries.

Table 7.6 A Roman code which is in use in the USA and United Kingdom.
Source: Frykholm and Lysell (1962)

Roman	Surfaces
I	occlusal/pits/fissures
II	proximal for premolar/molar
III	proximal for incisor/canine
IV	proximo-incisal
V	gingival

System D. This system makes use of signs such as lines or dots to indicate the location of the surface (Figure 7.18)(106). This system is found in the United Kingdom and some other countries.

Example

Figure 7.18 Example showing a filling covering the mesial, occlusal and distal surfaces of the lower right first molar.

System E **2^n - CODE System**

2^n - CODE System was a designation code for tooth surfaces which was brought to the FDI working group on Forensic Odonto-Stomatology at the FDI General Assembly in 1968 by Falkeisen (as cited by Keiser-Nielsen in 1982)[159]. This system required all five surfaces to be consecutively numbered by the figures 1, 2, 4, 8, and 16 (from 2 in the Nth power where N is equal to 0, 1,2, 3 and 4). The intermediate numbers between those already used up to number 31 were allocated through combinations between lower numbers which indicated more than one surface as shown in Table 7.7.

Table 7.7 2^n - CODE System for designation of tooth surfaces.
Source: Keiser-Nielsen (1982)

2^n - CODE System	Surface
$2^0 = 01$	O
$2^1 = 02$	M
$2^2 = 04$	D
$2^3 = 08$	V
$2^4 = 16$	L
03	MO
05	DO
06	MD
07	MOD
09	OV
10	MV
11	MOV
12	DV
13	DOV
14	MDV
15	MODV
17	OL
18	ML
19	MOL
22	MDL
25	VOL
30	MDVL
31	MODVL

7.1.5 Summary

The importance of correct registration and its significance is most obvious for the purpose of forensic dental identification in order to reduce the dangers of unnecessary mistakes in the identification process. Thus, correct interpretation of the symbols, abbreviations and codes used to record dental information is a critical factor in determining the dental evidence available in the identification processes.

The FDI Two-Digit System has been used in almost the entire world except the USA. The American Dental Association adopted the Universal System which had been widely used in that country by various bodies such as insurance organisations, dental schools and others. However, the FDI Two-Digit System has several advantages over the other systems:

a. It is the simplest method of dental notation for teaching and is easy to understand.

b. It is easy to translate in print, type, as well as being compatible with computer language.

c. It is easy to adapt to standard charts used in general practice, is accepted by international dental organisations and by the International Police (INTERPOL).

d. It helps to prevent errors when differentiating between left and right sides of the mouth or between upper and lower dental arches.

e. In speech, all automatically similar teeth in different quadrants have the same second digit, so that mention of say 'all the sixes' can be used effectively and simply for descriptive purposes, i.e it is readily communicable in conversation and dictation.

7.2 SOME EXAMPLES OF ODONTOGRAMS IN USE

7.2.1 The Malaysian Armed Forces Dental Card - BAT F3

DENTAL HISTORY CARD (BAT F.3)

Personal/Army No	Rank	Surname and Initial	Regt/Corps	Unit	Date of Birth	Date of Enlistment	Period of Engagement

PART 1 BUCCAL DENTAL CONDITION ON ENLISTMENT BUCCAL *To be entered in pencil

BUCCAL Existing dentures as under (if none strike through grid) BUCCAL

Oral Condition.................................... 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 BUCCAL

BUCCAL BUCCAL

Dental Centre No and Location	Ref. No	Date	Treatment	Initials of D.O.	Dental Centre No and Location	Ref. No	Date	Treatment	Initials of D.O.

Figure 7.19 The MAF dental history card - BAT F3.
Source: AFMATI (1976)

7.2.2 The Proposed BAT F3 (Amended 1991)

MEDICAL-IN-CONFIDENCE

BAT F3 (Amended 1991)

DENTAL CONDITION ON ENLISTMENT

To be done in Duplicate

Folio No

Service No	Rank*	Name	Regt/Corp	Unit/Ship*	Date of Birth	Date of Enlistment	Priod of engagement

* To be entered in pencil

Periodontal condition: Localised/Generalised Moderate:Severe Pocket: Present/Absent

Calculus: Localised/Generalised Slight/Moderate/Heavy Gingival condition: Satisfactory/UnSatisfactory

Existing denture (If any): Material:......................................

Indicate natureal 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

Figure 7.20 The proposed MAF dental history card BAT F3 (dental condition on enlistment).

MEDICAL-IN-CONFIDENCE

BAT F3 (Amended 1991)

DENTAL CONDITION ON ENLISTMENT

To be done in Duplicate Folio No

Service No	Rank*	Name	Regt/Corp	Unit/Ship	Date of birth	Date of Enlistment	Priod of engagement

* To be entered in pencil

Date	Dental centre	Treatment	Initial of D.O	Date	Dental centre	Treatment	Initial of D.O

MEDICAL-IN-CONFIDENCE

Figure 7.21 The proposed MAF dental history card BAT F3 (reverse).

7.2.3 The INTERPOL Victim Identification Form Part J

VICTIM IDENTIFICATION FORM PART

(Approved by the International Criminal Police Organisation - Interpol)

MALE/FEMALE REF. NO

DEAD BODY - DENTAL FINDINGS

11		21	
12		22	
13		23	
14		24	
15		25	
16		26	
17		27	
18		28	

48		38	
47		37	
46		36	
45		35	
44		34	
43		33	
42		32	
41		31	

Specific description of crowns, bridges and dentures

Further finding (Occlusion, attrition, anomalies, staining, calculus, periodentitis, etc)

Radiographic examination of

Supplementary examination

Age evaluation (Method?)

Figure 7.22 INTERPOL format of victim identification form Part J (front).
Source: Manual on Disaster Victim Identification (1984)

VICTIM IDENTIFICATION FORM PART

(Approved by the International Criminal Police Organisation - Interpol)

MALE/FEMALE	REF. NO.

DEAD BODY - DENTAL FINDINGS

Site of recovery:	Recovery No.:
Police Agency:	Date:

DENTAL EXAMINATION

Requested on		by
Performed by		at

MATERIAL

Jaws present		upper		lower	Removed		Yes		No
Fragmentary remains...............					Removed		Yes		No
Single teeth.........					Removed		Yes		No
Other..................					Removed		Yes		No

SUPPLEMENTARY DETAILS

Stamp	Place and date
	Signature

Figure 7.23 INTERPOL format of victim identification form Part J (reverse).
Source: Manual on Disaster Victim Identification (1984)

7.2.4 The United States Military Dental Records

Standard Form 603
Rev. November 1953
Bureau of the Budget
Circular A-32 (Rev)

HEALTH RECORD | **DENTAL**

SECTION I. DENTAL EXAMINATION

1. PURPOSE OF EXAMINATION						2. TYPE EXAM.				3. DENTAL CLASSIFIC'N				
	INITIAL		SEPERATION		OTHERS	1	2	3	4	1	2	3	4	5

4. MISSING TEETH AND EXISTING RESTORATIONS

REMARKS

PLACE OF EXAMINATION | DATE

SIGNATURE OF DENTIST COMPLETING THIS SECTION

4. DISEASE, ABNORMALITIES AND X-RAY

A. CALCULUS

| | SLIGHT | | MODERATE | | HEAVY |

B. PERIODONTOCLASIA

| | LOCAL | | GENERAL |

| | INCIPIENT | | MODERATE | | SEVERE |

C. STOMATITIS *(Specific)*

| | GINGIVITIS | | VINCENT'S |

D DENTURES NEEDED
(include denture needed after indicated extraction)

FULL		PARTIAL	
U	L	U	L

ABNORMALITIES OF OCCLUSION-REMARKS

E. INDICATE X-RAYS USED IN THIS EXAMINATION

| | FULL MOUTH PERIAPICAL | | POSTERIOR BITE-WINGS | | OTHER |

DATE | PLACE OF EXAMINATION | SIGNATURE OF DENTIST COMPLETING THIS SECTION

SECTION II. PATIENT DATA

6. SEX	7. RACE	8. RATING OR POSITION	9. ORGANITATION	10.COMPONENT/BRANCH	11.DEPT/AGENCY

12. PATIENT'S LAST NAME- FIRSTNAME - MIDDLE NAME	13. DATE OF BIRTH (DMY)	14. IDENTIFICATION NO.

DENTAL
standard form 603
603-102

Figure 7.24 United States Military dental form No. 603 (front). Source: Mertz (1977)

SECTION III. ATTENDANCE RECORD

15. RESTORATIONS AND TREATMENT *(complete during service)*	16. SUSEQUENT DISEASE AND ABNORMALLITIES
REMARKS	REMARKS

17. SERVICES RENDERED

DATE	DIAGNOSIS-TREATMENT	CLASS	OPERATOR AND DENTAL FACILITY	INITIALS	
					PATIENT NAME

GPO: 1969-c48-16-80366-1

Figure 7.25 United States Military dental form No. 603 (reverse).
Source: Mertz (1977)

7.2.5 Ante-Mortem Dental Record Red No. DF-3

NAME__________ DATE__________ 19______
ADDRESS__________ PHONE__________
PHYSICIAN__________ ESTIMATE $__________

DATE			TOOTH NO	DESCRIPTION OF WORK	TIME	ACCOUNT RECORD		
M	D	Y				DEBIT	CREDIT	BALANCE

Figure 7.26 Red No. DF-3 is an an example of a typical ante-mortem dental chart.
Source: Mertz (1977)

7.2.6 Form Used By British Forensic Odontologist To Record Ante-Mortem And Post-Mortem Dental Data

AM

SURNAME GIVEN NAME

ADDRESS D.O.B. SEX

IDENTIFIED AS BODY NO.

51	11			21	61
52	12			22	62
53	13			23	63
54	14			24	64
55	15			25	65
	16			26	
	17			27	
	18			28	

	48			38	
	47			37	
	46			36	
85	45			35	75
84	44			34	74
83	43			33	73
82	42			32	72
81	41			31	71

Description of crowns, bridges, dentures, orthodontics, occlusion, attrition, anomalies, staining, calculus, perio etc

DENTIST LAST EXAM DATE

ADDRESS DENTIST CONTACTED BY

PHONE CHART ENTERED BY

FAX CHART ENTERED BY

SURGERY TELEPHONE CHART CHECKED AGAINST ACTUAL DENTAL RECORDS BY

HOME TELEPHONE RADIOGRAPHS AVAILABLE?

Figure 7.27 Form used to record ante-mortem dental data.
Source: Clark (1992)

PM

EXAMINATION BY BODY NUMBER

CHARTED BY

DATE AND TIME SEX

51	11			21	61
52	12			22	62
53	13			23	63
54	14			24	64
55	15			25	65
	16			26	
	17			27	
	18			28	

	48			38	
	47			37	
	46			36	
85	45			35	75
84	44			34	74
83	43			33	73
82	42			32	72
81	41			31	71

Specific data on crowns, bridges and dentures

Further data (occlusion, attrition, anomalies, smoker, periodental status etc)

JAWS REMOVED? COMPUTER REFERENCE

RADIOGRAPHED? GRID REFERENCE

PHOTOGRAPHED? SEAT NUMBER

IDENTIFIED AS

SURGERY TELEPHONE

Figure 7.28 Form used to record post-mortem dental data.
Source: Clark (1992)

7.2.7 Form Used By Forensic Odontology Unit, University of Adelaide To Record Ante And Post-Mortem Dental

The University of Adelaide **Forensic Odontology Unit**

DENTAL STATUS OF MISSING PERSON

Date:........................

Name Age: D.O.B: M/F

Address:

Previous Addresses:

Dentists

Occupation:

School Clinic
Hospital

Police Reference: Reference F/O:

11			21
12			22
13			23
14			24
15			25
16			26
17			27
18			28

48			38
47			37
46			36
45			35
44			34
43			33
42			32
41			31

Occlusion: Crowns: Bridges: Smoke?

DENTURES: P/U F/U P/L F/L Material: Marks: TEETH: Type: Mould: Shade: CLASPS: Type:

RADIOGRAPHS Bw Pa Occ Lat. AP OPG
PHOTOGRAPHS Clinical Portrait

SPECIAL TREATMENT Endo. Perio. Ortho. Oral Surgery C. & B.

(Form 1)

Figure 7.29 Form used to record ante-mortem dental data.
Source: Forensic Odontology Unit, University of Adelaide

The University of Adelaide **Forensic Odontology Unit**

DENTAL STATUS OF HUMAN REMAINS

Site of Discovery: Condition of Remains: Cause of Death:	Date: Body No: Ref. F/O Sex:

Pathologist: Police Ref:

11			21
12			22
13			23
14			24
15			25
16			26
17			27
18			28

48			38
47			37
46			36
45			35
44			34
43			33
42			32
41			31

Occlusion: Crowns: Bridges: Smoke?

DENTURES: P/U F/U — P/L F/L Material: Marks: TEETH: Type: Mould: Shade:

CLASPS: Type:

UNIQUE FEATURES Perio Condition Specialist Treatment Smoker?

ESTIMATED AGE POSSIBLE I.D.:

(Form 2)

Figure 7.30 Form used to record post-mortem dental data.
Source: Forensic Odontology Unit, University of Adelaide

7.3 INITIAL QUERY ENTITIES TYPES

In general this system consist of 4 major entities: Departmental Records, Clinical Records, Computer Assisted Dental Identification Systems and Utility.

Departmental Records

a. AFDC/Department

b. Employee

c. Work-History

d. Dependant

e. Wages/Salary

Clinical Record

a. Patient Record

b. Dependant

c. Medical History

d. Clinical Record

e. Procedure

f. Appointment

Computer Assisted Dental Identification System

a. Ante-mortem Data

b. Post-mortem Data

c. Special Features

d. Disaster Identity

e. Odontogram

Utility

a. Correspondance

Referral Form
Address
Recall Note

b. Statistical Analysis

Dental Return
Expenditure
Stock Control

c. Inventory

Material/Equipment
Supplier
Maintenance
Stock Level

7.3.1 Department Record

1.	**AFDC**	***AFDC** Location Address Phone Fax Officer Command Svc No Mail From Subject Priority
2.	**EMPLOYEE**	***Svc No** Rank Name Unit HomeAddress Phone DBirth Gender Date of Enlistment Date of Retirement Insurance No AFDC Marital Status Position Qualification
3.	**DEPENDANT**	***Dependant Name** ***Dependant ID** Svc No Gender DBirth Relationship Address
4.	**NOTE BOOK**	***Note Date** Description Name Note

7.3.2 Clinical Records

5.	**PATIENT**	***Svc No** Rank Name Unit Category Address Phone DBirth Gender Date of Enlistment Date of Retirement Insurance No Marital Status Last Visit

This is the dental record on joining and once data has been entered, it cannot be erased (Including odontogam).

6.	**DEPENDANT**	***Dependant Name** ***Dependant ID** Svc No Gender DBirth Relationship Address Last Visit

7.	**MED HISTORY**	Asthma Allergy:Drugs, Food, Substance, Animals Blood related diseased: Heart Problem: Diabetes Epilepsy Hepatitis Kidney related problem: Drugs Taken: Personal Doctor: Contact No.

8.	**CLINICAL RECORD**	Entry No		
		Date		
		Tooth		
		Description	Treatment	
			Material	
			Surface	
		Desc Code		
		Dentist		
		Remark		
		Appointment		
9.	**ODONTOGRAM**	Examination		
		Procedure		

10. <u>ODONTOGRAM FOR CLINICAL EXAMINATION</u>

STATUS	Intact		
	Missing (AM/PM)		
	Caries		
	Unerupted		
	Impacted		
	Fracture		
	Retained Root		
	For Extraction		
	Extracted		
	Not Recorded		
TREATMENT	Inlay		
	Crown		
	Bridge		
	Pontic		
	Temp. Filling		
	Class I, II, III, IV, V		
	Fissure sealant		
	Endodontics		
	PostCrown		
	Implant:		
	Denture	Partial	Upper
			Lower
		Full	Upper
			Lower

	SURFACE	Mesial Distal Occlusal Vestibular Lingual
	MATERIAL	Amalgam Tooth Colour:compomer Porcelain Gold Acrylic Silver GlassIonomer Temporary
	FITNESS	Fit UnFit
11.	**PROCEDURE**	Endodontic Preventive Prosthodontic Orthodontic Periodontic Oral Medication OralSurgery (Implant) X-Ray
	ENDODONTIC	Pulpotomy Pulpectomy Apex Seal Pulp Capping Medication

ORTHODONTIC

***Svc No**
Rank
Name
Unit
Age
DBirth
Gender
Address
Phone
Skeletal Pattern
FMPA
Soft Tissue
Angles
Over Bite
Over Jet
Centre Line
Tooth Quality
Crowding
MAL Position
Diagnosis
Treatment Plan
Study model
Extraction
Tooth Present
X-Ray
Orthodontist

PREVENTIVE

Scaling
Polishing
Flouride Application
Fissure Sealant
OHI

PERIODONTIC

Gingivoplasty
Gingivectomy
Root Planning
Deep Scaling

PROSTHODONTIC	First Impression Bite Regestration Second Impression First Try-In Second Try-In Issue Adjustment Alginate Rubber Base Acrylic Crome-Cobalt	
ORAL MEDICATION	Analgesic	Paracetamol Ponstan
	Antibiotic	Penglobe Flagyl Ampicillin Pen V Erythromycin
	Antinflamation	Papase
ORAL SURGERY	LA Extraction MOS Implant Alveoloplasty Alveolectomy Frenectomy Apicectomy STO	
X-RAY	OPG Periapical Bitewing Lateral Skull Posterioanterio Occlusal Digital Imaging	

12.	**APPOINTMENT**	***Appointment No** Date Entry No Time Svc No Name Dentist Procedure

Schedule for multiple days and multiple dentist (MS Schedule)

7.3.3 Computer Assisted Dental Identification

13.	**FORENSIC CASES**	***CaseId**
		***Year**
		Site
		Date of Incident
		Date of Examination
		Date of End Examination
		No. of suspect Victims
		No.. of Recovered
		No. of Missing
		No. of Identifed
		No. of Unidentifed
		Forensic Odontologist
14.	**ANTE-MORTEM**	***Ante-Mortem No**
		***Svc No**
		Rank
		Name
		Address
		DBirth
		Gender
		Last Visit
		AFDC
		Age
		Date Received
		Odontologist
15.	**POST-MORTEM**	***Body No**
		***F/O No**
		CaseId
		Police Ref No
		Site of Discovery
		Cause of Death
		Condition
		Date of Examination
		Forensic Odontologist
		Pathologist

16.	**SPECIAL FEATURE**	Occlusion	
		Attrition	
		Oral Condition	
		Smoke (Y/N)	
		Denture: (UP, LP, UF, LF)	
		Denture	Acrylic
			Chrome Cobalt
		Other	

17. ODONTOGRAM FOR FORENSIC IDENTIFICATION

STATUS	Intact	
	Caries	
	Unerupted	
	Impacted	
	Fracture	
	Retained Root	
	Extracted	
	Missing	AM
		PM/ Not Recovered
	Not Recorded	
MATERIAL	Amalgam	
	Tooth Colour	
	Porceline	
	Gold	
	Acrylic	
	Silver	
	GlassIonomer	
	Kalzinol	
	PolyF	
SURFACE	Mesial	
	Distal	
	Occlusal	
	Vestibular	
	Lingual	

	TREATMENT	Inlay Crown Pontic TempFilling Fissure sealant Endodontics PostCrown Bridge Implant Prosthodontic Orthodontic
18.	**LIST OF AM**	***Ante-mortem No** Entry No Svc No Name Address Gender Age AFDC
19.	**LIST OF PM**	***Cases No** Entry No Body No F/O No Gender
20.	**LIST OF MATCHES**	*Top ten according to the 192 different number of comparison (Less different at the top of the list, base on 32 teeth and 160 surfaces).*

7.3.4 Utility

21.	**RECEIPT**	***Receipt No** Date AFDC Svc No Name Description Amount Term Balance
22.	**MEDICAL LEAVE**	***Medical Leave No** Date AFDC Svc No Name Address From To Treatment Next App Dentist
23.	**REFERRAL FORM**	***Referral No** Date AFDC Dentist Referral/Procedure Svc No Name Note

24.	**LAB FORM**	***Form No** AFDC Name Rank Svc No Address Ph: Office/house Description: Denture, Bridge, Crown, Inlay/onlay, Implant, Ortho Shade No First Impression Special Tray Secondary Impression Bite Registration First Try-In Second Try-In Issue Appointment Dentist Technician Remark
25.	**ORDER FORM**	***Order No** Date AFDC Item Name Quantity Unit Price Total
26.	**ADDRESS LABEL**	Name Address Phone Fax Category: Civilian, Armed Forces Pesonnel,Dependent

27.	**RETURN**	***Return No**				
		Month				
		Category				
		Amalgam Class		I	II	V
		Composite Class		I	IV	V
		Crown				
		Bridge				
		Temporary				
		Filling				
		Scaling / Polishing				
		OHI				
		Fluoride Application				
		Fissure Sealant				
		Endodontic				
		Local Anaesthetic				
		Minor Oral Surgery				
		Prosthetic	Acrylic	Partial/Full		
			Cr-Co	Partial		
			Adjustment			
		Orthodontic	New Patient			
			Adjustment			
			Complete			
		Oral Pathology				
		Miscellaneous	Oral Medicine			
			Impression			
			Xray			
		Examination/Diagnosis				
		Total Work Done				
		Total Attendance				
28.	**Memo**	Date				
		To				
		From				
		Ref				
		CC				
		Message				

29.	**FAX FORMATE**	**AFDC** Date Phone Fax Fax From Phone Fax Ref: CC: No. Of Pages Message
30.	**EXPENDITURE**	***Leger No** AFDC Month Income Stock Usage Wages Phone Bill Electricity Miscellaneous Bring Forward
31.	**STOCK**	***Category:** Conservative, Prosthodontic, Orthodontic, Oral med, etc ***Itemtype:** non/Expendable ***Part No** ***Item Name** Unit Price Order No Total Order Supplier ID Date Manufacture Date Expire Maintenance Unit In Stock Issue In Issue Out Date Last Stock Check

32.	**SUPPLIER**	***SupplierID** ***Supplier Name** Address Phone Fax Account No Part No Note
33.	**MAINTENANCE**	***WorkID** Item Name Part No Last Svc Supplier ID MName Work Description Part Replace Authority Next Svc Cost Remark
34.	**INCOME**	*Payment Date EntryNo Name Treatment Description Amount Balance Term of Payment

35.	**VOTBOOK**	***VOTID** Date Description Bringforward Debit Code [(S.O.D.O)/(Objek Sebagai)] Invoice/Voucher No. Debit Credit DebitCharge (Tanggungan dikenakan) Debit in Hand Net Cost (Perbelanjaan Bersih) Balance (Baki masih Ada)

7.4 AN EXAMPLE OF EXECUTION OF THE ODONTID© PROGRAMME

C>

C> cd odont

C> odontv5

ODONTOLOGICAL RECORDS PROGRAM

COPYRIGHT T. R. ELLIOT 23/5/1985

POST-MORTEM RECORDS - OPTIONS

1. ADD NEW RECORDS
2. UPDATE records
3. DISPLAY records
4. CHANGE work file
5. COMPARE post-mortem and ante-mortem records
6. END PROGRAM

CHOOSE OPTION 1

DO YOU WISH TO USE POST-MORTEM OR ANTE-MORTEM FILE (p/a)? a

ENTER NAME OF ANTE-MORTEM FILE - DO NOT USE EXTENSION

missin10_ _

FAMILY NAME : ALI _______________

GIVEN NAME : ABU_______________

ADDRESS : 1-21 EDWARD STREET________

SUBURRB/CITY : GLYNDE ____________

POSTCODE : 5080_______________

DATE OF BIRTH : 01-01-70_____________

SEX (M/F) : F_

DATE LAST VISIT : 12-12-96__

RECORD NUMBER 6

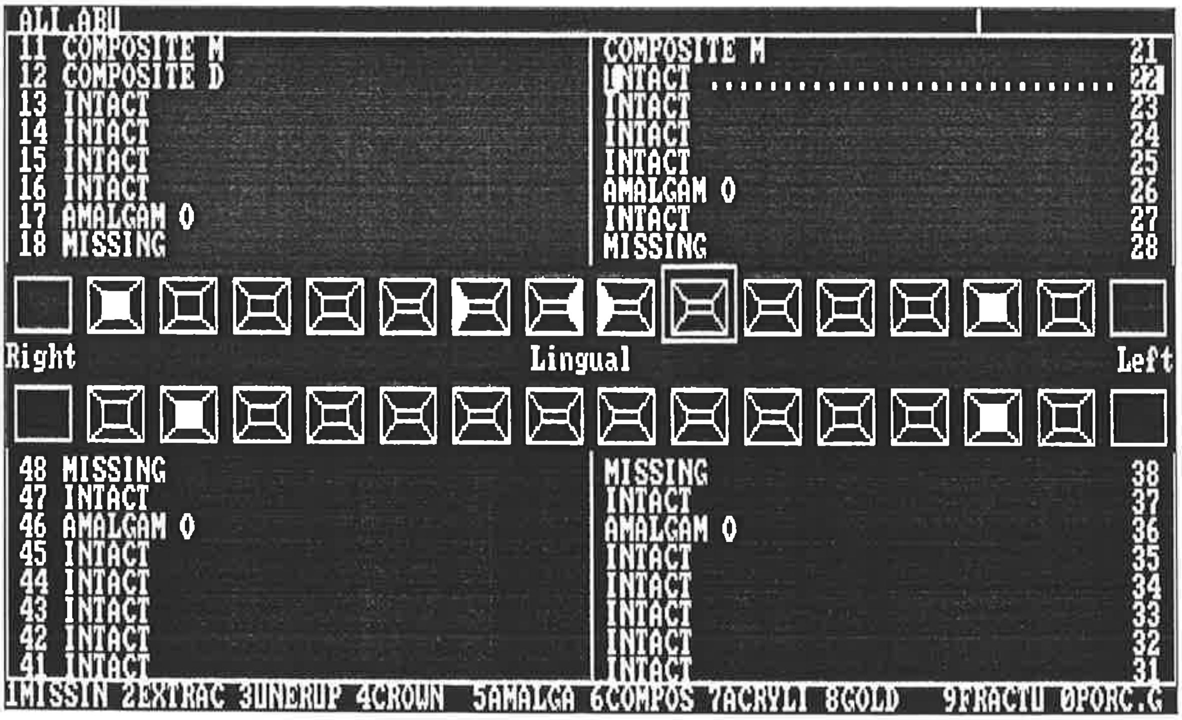


Figure 7.31 Ante-mortem odontogram.

NAME : ALI , ABU

OCCLUSION : _ ___ PERIO. CONDITION : ____ SMOKE ((Y/N) : _

DENTURE (PU/PL/FU/FL) : ______ TEETH type : ___ _______

material : _ _ ___ mould : ___________

marks : _ _____ shade : ___________

CLASPS type : ______

TREATMENT PLAN : _______________________________

COMMENTS : ___________________________________

X-RAY : _______________________________________

PRESS <ALT S> TO SAVE DATA

PRESS ESC

POST-MORTEM RECORDS - OPTIONS

1. ADD new records
2. UPDATE records
3. DISPLAY records
4. CHANGE work file
5. COMPARE post-mortem and ante-mortem records
6. END PROGRAM

CHOOSE OPTION 4

DO YOU WISH TO USE POST-MORTEM OR ANTE-MORTEM FILE (p/a)? p

ENTER NAME OF POST-MORTEM FILE - DO NOT USE EXTENSION

CASES10_ _

POST-MORTEM RECORDS - OPTIONS

1. ADD new records
2. UPDATE records
3. DISPLAY records
4. CHANGE work file
5. COMPARE post-mortem and ante-mortem records
6. END PROGRAM

CHOOSE OPTION 1

BODY NUMBER	:	100234 ____
POLICE REFERENCE	:	_________
FORENSIC ODONT. REF	:	97/75 _____
DATE OF EXAMINATION	:	12-01-97
SITE OF DISCOVERY	:	Henly Beach _______________
CONDITION OF REMAINS	:	Decomposed _____
CAUSE OF DEATH	:	Suicide _________
PATHOLOGIST	:	Dr R. JAMES

RECORD NUMBER 6

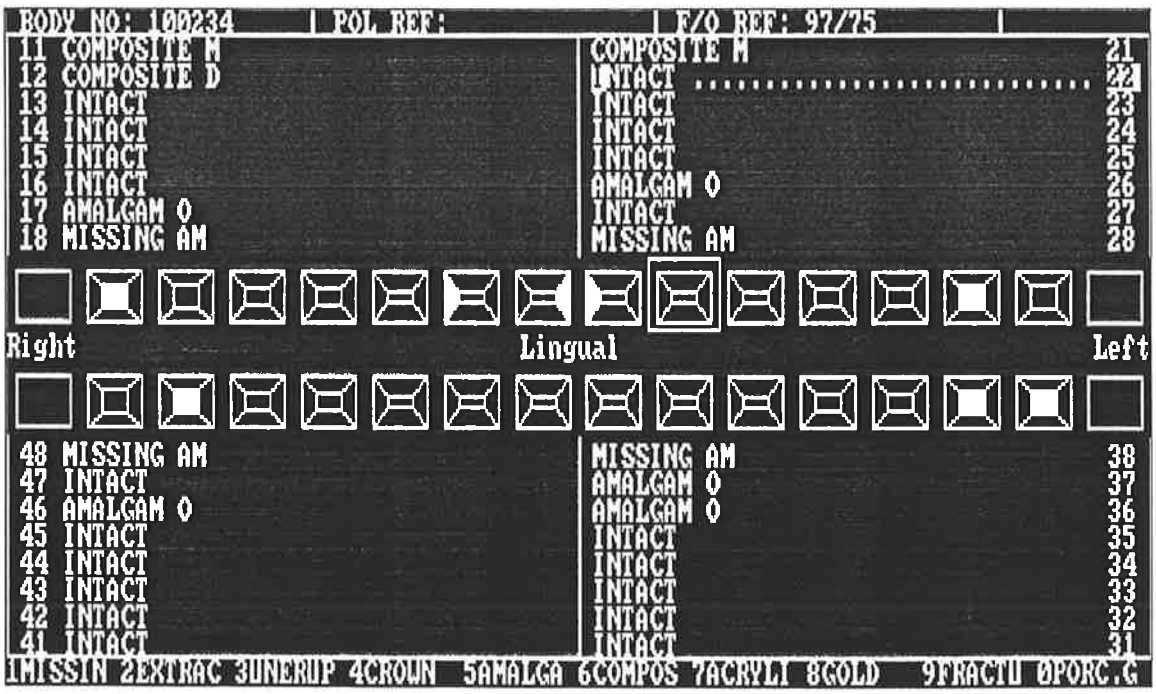


Figure 7.32 Post-mortem Odontogram.

BODY NO : 100234

OCCLUSION : ____ PERIO. CONDITION : ____ SMOKE ((Y/N) : _

DENTURE (PU/PL/FU/FL) : _____ TEETH type : ___________

material : ______ mould : ___________

marks : ______ shade : ___________

CLASPS type : ______

TREATMENT PLAN : _______________________________

COMMENTS : __________________________________

X-RAY : ______________________________________

PRESS <ALT S> TO SAVE DATA

PRESS ESC

POST-MORTEM RECORDS - OPTIONS

1. ADD new records
2. UPDATE records
3. DISPLAY records
4. CHANGE work file
5. COMPARE post-mortem and ante-mortem records
6. END PROGRAM

CHOOSE OPTION 5

ENTER NAME OF ANTE-MORTEM FILE - DO NOT USE EXTENSION

MISSIN10_ _

ENTER NAME OF POST-MORTEM FILE - DO NOT USE EXTENSION

CASES10_ _

DO YOU WANT TO LIST TO LINE PRINTER? (Y/N) N

DO YOU WANT TO SAVE MATCHES ON DISK? (Y/N) Y

ENTER NAME OF SAVE FILE

COMPFILE.CMP _ _

PRESS CTRL-PgDN

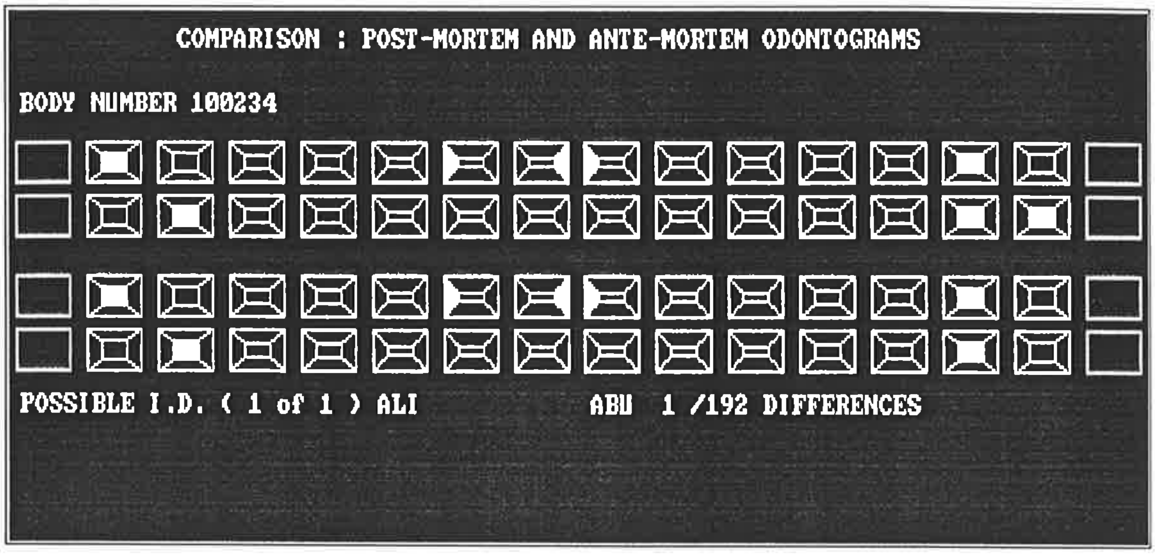


Figure 7.33 Comparison of post-mortem and ante-mortem odontograms.

PRESS U

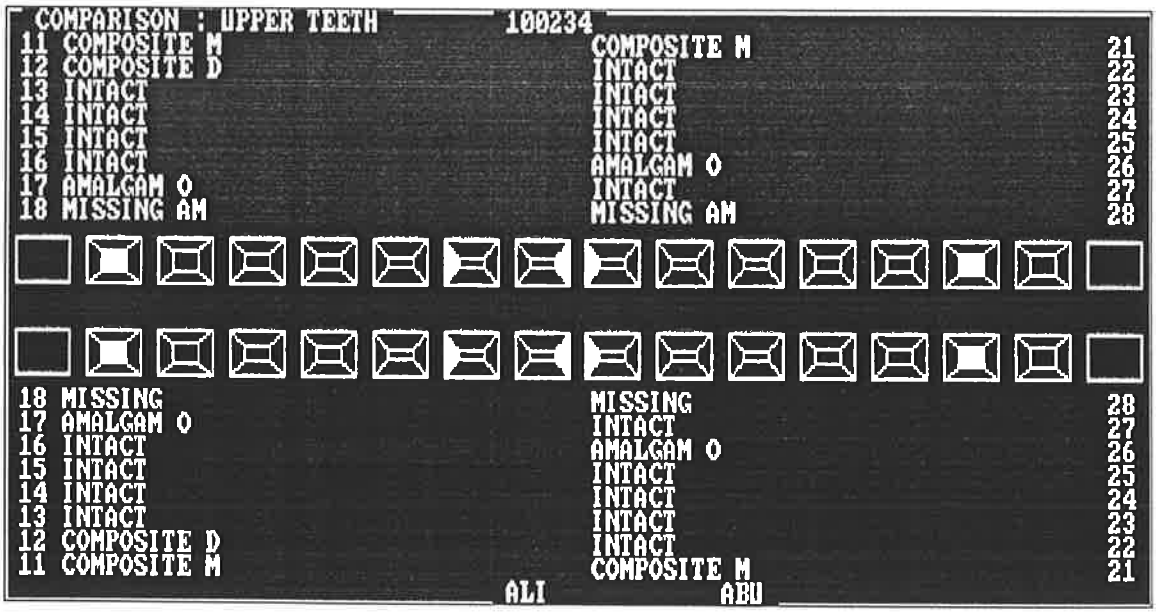


Figure 7.34 Comparison of upper post-mortem and ante-mortem odontograms.

PRESS L

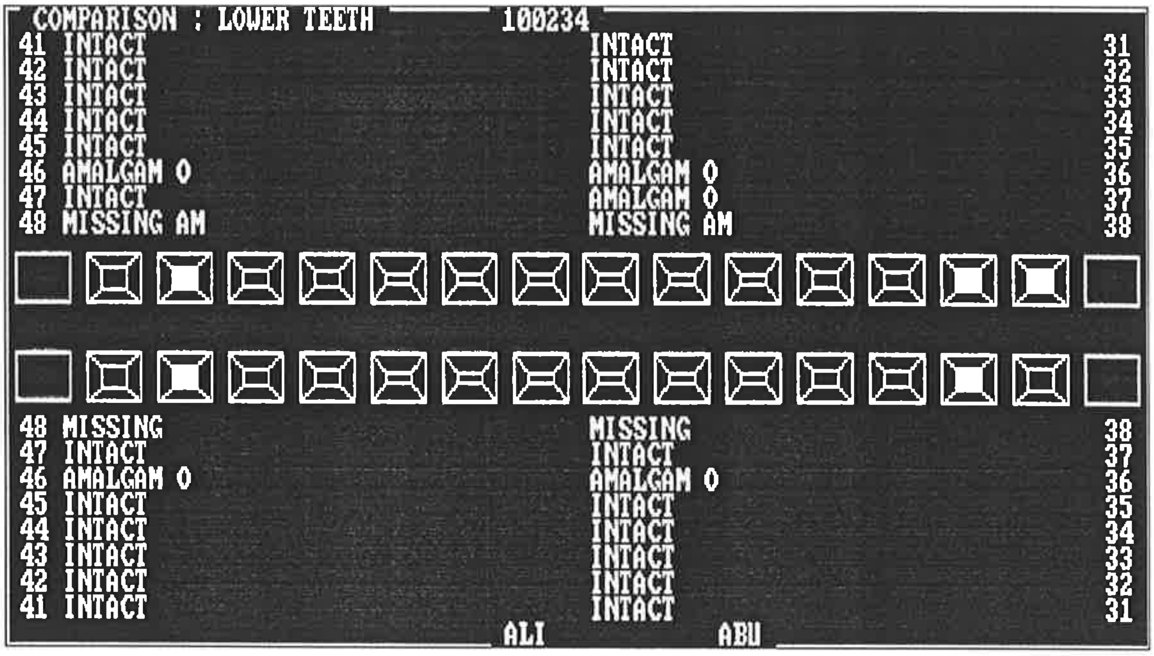


Figure 7.35 Comparison of lower post-mortem and ante-mortem odontograms.

PRESS F18 TO PRINT ODONTOGRAMS

PRESS ESC

POST-MORTEM RECORDS - OPTIONS

1. ADD new records
2. UPDATE records
3. DISPLAY records
4. CHANGE work file
5. COMPARE post-mortem and ante-mortem records
6. END PROGRAM

CHOOSE OPTION 2

DO YOU WISH TO USE POST-MORTEM OR ANTE-MORTEM FILE? (P/A) P

ENTER NAME OF POST-MORTEM FILE - DO NOT USE EXTENSION

CASES10_ _

UPDATE RECORD BY NAME OR RECORD NUMBER? (N/R) N

ENTER FORENSIC ODONTOLOGY REFERENCE NUMBER : 97/15 _ _ _ _ _

BODY NUMBER	:	100234 _ _ _ _
POLICE REFERENCE	:	_ _ _ _ _ _ _ _ _ _
FORENSIC ODONT. REF	:	97/75 _ _ _ _ _
DATE OF EXAMINATION	:	12-01-97
SITE OF DISCOVERY	:	Henly Beach _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
CONDITION OF REMAINS	:	Decomposed _ _ _ _ _
CAUSE OF DEATH	:	Suicide _ _ _ _ _ _ _ _
PATHOLOGIST	:	Dr R. JAMES

PRESS ESC

POST-MORTEM RECORDS - OPTIONS

1. ADD new records
2. UPDATE records
3. DISPLAY records
4. CHANGE work file
5. COMPARE post-mortem and ante-mortem records
6. END PROGRAM

CHOOSE OPTION 3

DISPLAY NAME ONLY OR FULL RECORD? (N/F) N

PRINT NAME TO PRINTER? (Y/N)

1.	93/39	2.	93/37
3.	93/49	4.	93/50
5.	10/22	6.	97/15

7.5 THE CODE USED FOR MATCHING ALGHORITHM OF ODONTID PROFESSIONAL©

```
Option Compare Database
Option Explicit

'Declare a Record Type and a Dynamic Array for use with
"CountDifferences"
Type TDifference
    strServiceNumber As String
    bTotalDifferences As Byte
    b1QuadrantDiff    As Byte
    b2QuadrantDiff    As Byte
    b3QuadrantDiff    As Byte
    b4QuadrantDiff    As Byte
    bSpecialConsid    As Byte
    bToothSurface     As Byte
    'This type maintains the total differences encountered with each
    'comparision pass between the PM and AM records.
    'It also maintains a count of differences in each quadrant,
    'and any special considerations that may need to be taken into
    'account.
End Type

Type arr_TDifference
     arr_DynTDifference() As TDifference
End Type

'Declare a record type that holds the five faces of a tooth
'Will be used to check differences
Type TToothFace
    Lingual As String
    Mesial As String
    Distal As String
    Occusal As String
    Vestibular As String
End Type


'*****************************************************************
'*****************************************************************

Function RecordCounter(tblActiveTable As String) As Integer
'Author: Microsoft Programming Team
'Modifications and Integration:
'Nikolaos Vogiatzis BSc(Ma & Comp Sc), MBA(Technology Management) in
progress
'Serial: 9704251510
'Purpose: To Count the number of Records in any table
'Development History:
'*****************************************************************
'   V1.0.0. 25th of April, 1997, Utility Function
'   Future Development:
'       No Future Development Planned
```

```
'*******************************************************************
Dim dbs As Database, rst As Recordset

' Return reference to current database.
Set dbs = CurrentDb
' Open Dynaset Recordset object, and populate it
Set rst = dbs.OpenRecordset(tblActiveTable, dbOpenDynaset)
rst.MoveLast
' Use RecordCount to Count Recs
RecordCounter = rst.RecordCount
rst.Close
Set dbs = Nothing
End Function

'*********************************************************************
'*********************************************************************

Function CountDifferences() As arr_TDifference
'Author: Nikolaos Vogiatzis BSc(Ma & Comp Sc),
'        MBA(Technology Management) in progress
'Serial: 9704251638
'Purpose:
'     To perform a generic search of the database for differences
between
'   AM Form and PM Form
'Development History:
'*********************************************************************
'   V1.0.0. 25th of April, 1997.  Test function:
'   Searches entire odontogram.
'   Future Development:
'       V1.x.x splits up odontogram.
'   V1.0.2  19th of May, 1997
'   Fixed up subscript problem by ensuring that the double loop at the
'   end of the function moved to the next record
'   V1.1.0  23rd of May, 1997
'    Uses the function FieldPaser to parse the field and then check
differences
'     against each tooth surface.   Reports back both total tooth
differences
'   and surface differences
'   V1.2.0  1st of June, 1997
'    Function Fieldparser changed to fsmFieldParser, and re-written
using a
'   Finite State Machine
'*********************************************************************

'   Define Tables and variables required for search
Const dbsAM As String = "Odontogram"
Const dbsPM As String = "Odontogram2"

Dim dbs As Database
Dim tdfAMTable, tdfPMTable As TableDef
Dim rstAM As Recordset
Dim rstPM As Recordset
Dim ttfTempAM As TToothFace
Dim ttfTempPM As TToothFace
Dim fldAMsvcno As Field
Dim fldAM11, fldPM11 As Field
```

```
Dim fldAM12, fldPM12 As Field
Dim fldAM13, fldPM13 As Field
Dim fldAM14, fldPM14 As Field
Dim fldAM15, fldPM15 As Field
Dim fldAM16, fldPM16 As Field
Dim fldAM17, fldPM17 As Field
Dim fldAM18, fldPM18 As Field
Dim fldAM21, fldPM21 As Field
Dim fldAM22, fldPM22 As Field
Dim fldAM23, fldPM23 As Field
Dim fldAM24, fldPM24 As Field
Dim fldAM25, fldPM25 As Field
Dim fldAM26, fldPM26 As Field
Dim fldAM27, fldPM27 As Field
Dim fldAM28, fldPM28 As Field
Dim fldAM31, fldPM31 As Field
Dim fldAM32, fldPM32 As Field
Dim fldAM33, fldPM33 As Field
Dim fldAM34, fldPM34 As Field
Dim fldAM35, fldPM35 As Field
Dim fldAM36, fldPM36 As Field
Dim fldAM37, fldPM37 As Field
Dim fldAM38, fldPM38 As Field
Dim fldAM41, fldPM41 As Field
Dim fldAM42, fldPM42 As Field
Dim fldAM43, fldPM43 As Field
Dim fldAM44, fldPM44 As Field
Dim fldAM45, fldPM45 As Field
Dim fldAM46, fldPM46 As Field
Dim fldAM47, fldPM47 As Field
Dim fldAM48, fldPM48 As Field
'***
'Dim fldVictim As Field
'***
Dim iRnumAM, iRnumPM As Integer
'iRnumXX -> Count of Records of AM/PM rst
Dim bCountDiff As Byte
Dim bQ1Count, bQ2Count, bQ3Count, bQ4Count, bSpecCon, bTSurface As
Byte
'Counts the differences on each pass of the search
Dim iCtr As Integer
'simply an array indexer
Dim iMaxRetArrSz As Integer
'This returns the maximum size of the return difference array
'iMaxRetArrSz -> Maximum Return Array Size
Dim TDTempArr As arr_TDifference
'TDTempArr -> TDifference Temp Array
Dim TDiff As TDifference
'********************************************************************
'********************************************************************

'   Count the number of records in the AM and PM tables
iRnumAM = RecordCounter(dbsAM)
iRnumPM = RecordCounter(dbsPM)

'Test to see which is the count is bigger.  This will define the size
of the exit array
If iRnumAM > iRnumPM Then
```

```
    iMaxRetArrSz = iRnumAM
Else
    iMaxRetArrSz = iRnumPM
End If
ReDim TDTempArr.arr_DynTDifference(iMaxRetArrSz)

'Set the database, tabledefs,and field definitions
Set dbs = CurrentDb
'Set tdfAMTable = dbs.TableDefs!Odontogram
'Set tdfPMTable = dbs.TableDefs!Odontogram2
Set rstAM = dbs.OpenRecordset(dbsAM)
Set rstPM = dbs.OpenRecordset(dbsPM)
'Set field variables
Set fldAMsvcno = rstAM![SvcNo]
Set fldAM11 = rstAM![AMDesc11]
Set fldAM12 = rstAM![AMDesc12]
Set fldAM13 = rstAM![AMDesc13]
Set fldAM14 = rstAM![AMDesc14]
Set fldAM15 = rstAM![AMDesc15]
Set fldAM16 = rstAM![AMDesc16]
Set fldAM17 = rstAM![AMDesc17]
Set fldAM18 = rstAM![AMDesc18]
Set fldAM21 = rstAM![AMDesc21]
Set fldAM22 = rstAM![AMDesc22]
Set fldAM23 = rstAM![AMDesc23]
Set fldAM24 = rstAM![AMDesc24]
Set fldAM25 = rstAM![AMDesc25]
Set fldAM26 = rstAM![AMDesc26]
Set fldAM27 = rstAM![AMDesc27]
Set fldAM28 = rstAM![AMDesc28]
Set fldAM31 = rstAM![AMDesc31]
Set fldAM32 = rstAM![AMDesc32]
Set fldAM33 = rstAM![AMDesc33]
Set fldAM34 = rstAM![AMDesc34]
Set fldAM35 = rstAM![AMDesc35]
Set fldAM36 = rstAM![AMDesc36]
Set fldAM37 = rstAM![AMDesc37]
Set fldAM38 = rstAM![AMDesc38]
Set fldAM41 = rstAM![AMDesc41]
Set fldAM42 = rstAM![AMDesc42]
Set fldAM43 = rstAM![AMDesc43]
Set fldAM44 = rstAM![AMDesc44]
Set fldAM45 = rstAM![AMDesc45]
Set fldAM46 = rstAM![AMDesc46]
Set fldAM47 = rstAM![AMDesc47]
Set fldAM48 = rstAM![AMDesc48]
Set fldPM11 = rstPM![PMDesc11]
Set fldPM12 = rstPM![PMDesc12]
Set fldPM13 = rstPM![PMDesc13]
Set fldPM14 = rstPM![PMDesc14]
Set fldPM15 = rstPM![PMDesc15]
Set fldPM16 = rstPM![PMDesc16]
Set fldPM17 = rstPM![PMDesc17]
Set fldPM18 = rstPM![PMDesc18]
Set fldPM21 = rstPM![PMDesc21]
Set fldPM22 = rstPM![PMDesc22]
Set fldPM23 = rstPM![PMDesc23]
Set fldPM24 = rstPM![PMDesc24]
```

```
Set fldPM25 = rstPM![PMDesc25]
Set fldPM26 = rstPM![PMDesc26]
Set fldPM27 = rstPM![PMDesc27]
Set fldPM28 = rstPM![PMDesc28]
Set fldPM31 = rstPM![PMDesc31]
Set fldPM32 = rstPM![PMDesc32]
Set fldPM33 = rstPM![PMDesc33]
Set fldPM34 = rstPM![PMDesc34]
Set fldPM35 = rstPM![PMDesc35]
Set fldPM36 = rstPM![PMDesc36]
Set fldPM37 = rstPM![PMDesc37]
Set fldPM38 = rstPM![PMDesc38]
Set fldPM41 = rstPM![PMDesc41]
Set fldPM42 = rstPM![PMDesc42]
Set fldPM43 = rstPM![PMDesc43]
Set fldPM44 = rstPM![PMDesc44]
Set fldPM45 = rstPM![PMDesc45]
Set fldPM46 = rstPM![PMDesc46]
Set fldPM47 = rstPM![PMDesc47]
Set fldPM48 = rstPM![PMDesc48]
'*******************************************************************
'*******************************************************************

'Needs some setup routines
bCountDiff = 0
bQ1Count = 0
bQ2Count = 0
bQ3Count = 0
bQ4Count = 0
bSpecCon = 0
bTSurface = 0
iCtr = 0
'Search through the AM and PM tables and count the differences
rstAM.MoveFirst
rstPM.MoveFirst
Do Until rstPM.EOF
    Do Until rstAM.EOF
        If fldAM11 <> fldPM11 Then
            ttfTempAM = fsmFieldParser(fldAM11.Value)
            ttfTempPM = fsmFieldParser(fldPM11.Value)
            If ttfTempAM.Distal <> ttfTempPM.Distal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
                bTSurface = bTSurface + 1
            End If
            bCountDiff = bCountDiff + 1
            bQ1Count = bQ1Count + 1
            If ((fldAM11 <> Null) And (fldPM11 = "") _
```

```
            Or (fldAM11 = "") And (fldPM11 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM12 <> fldPM12 Then
        ttfTempAM = fsmFieldParser(fldAM12.Value)
        ttfTempPM = fsmFieldParser(fldPM12.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM12 <> Null) And (fldPM12 = "") _
            Or (fldAM12 = "") And (fldPM12 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM13 <> fldPM13 Then
        ttfTempAM = fsmFieldParser(fldAM13.Value)
        ttfTempPM = fsmFieldParser(fldPM13.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM13 <> Null) And (fldPM13 = "") _
            Or (fldAM13 = "") And (fldPM13 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM14 <> fldPM14 Then
        ttfTempAM = fsmFieldParser(fldAM14.Value)
        ttfTempPM = fsmFieldParser(fldPM14.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
```

```
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM14 <> Null) And (fldPM14 = "") _
            Or (fldAM14 = "") And (fldPM14 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM15 <> fldPM15 Then
        ttfTempAM = fsmFieldParser(fldAM15.Value)
        ttfTempPM = fsmFieldParser(fldPM15.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM15 <> Null) And (fldPM15 = "") _
            Or (fldAM15 = "") And (fldPM15 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM16 <> fldPM16 Then
        ttfTempAM = fsmFieldParser(fldAM16.Value)
        ttfTempPM = fsmFieldParser(fldPM16.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
```

```
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM16 <> Null) And (fldPM16 = "") _
            Or (fldAM16 = "") And (fldPM16 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM17 <> fldPM17 Then
        ttfTempAM = fsmFieldParser(fldAM17.Value)
        ttfTempPM = fsmFieldParser(fldPM17.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM17 <> Null) And (fldPM17 = "") _
            Or (fldAM17 = "") And (fldPM17 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM18 <> fldPM18 Then
        ttfTempAM = fsmFieldParser(fldAM18.Value)
        ttfTempPM = fsmFieldParser(fldPM18.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
```

```
        If ((fldAM18 <> Null) And (fldPM18 = "") _
            Or (fldAM18 = "") And (fldPM18 <> Null)) Then
            bSpecCon = bSpecCon + 1
            End If
        End If
        If fldAM21 <> fldPM21 Then
            ttfTempAM = fsmFieldParser(fldAM21.Value)
            ttfTempPM = fsmFieldParser(fldPM21.Value)
            If ttfTempAM.Distal <> ttfTempPM.Distal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
                bTSurface = bTSurface + 1
            End If
            bCountDiff = bCountDiff + 1
            bQ1Count = bQ1Count + 1
            If ((fldAM21 <> Null) And (fldPM21 = "") _
                Or (fldAM21 = "") And (fldPM21 <> Null)) Then
            bSpecCon = bSpecCon + 1
            End If
        End If
        If fldAM22 <> fldPM22 Then
            ttfTempAM = fsmFieldParser(fldAM22.Value)
            ttfTempPM = fsmFieldParser(fldPM22.Value)
            If ttfTempAM.Distal <> ttfTempPM.Distal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
                bTSurface = bTSurface + 1
            End If
            bCountDiff = bCountDiff + 1
            bQ1Count = bQ1Count + 1
        If ((fldAM22 <> Null) And (fldPM22 = "") _
                Or (fldAM22 = "") And (fldPM22 <> Null)) Then
            bSpecCon = bSpecCon + 1
            End If
        End If
        If fldAM23 <> fldPM23 Then
            ttfTempAM = fsmFieldParser(fldAM23.Value)
            ttfTempPM = fsmFieldParser(fldPM23.Value)
```

```
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM23 <> Null) And (fldPM23 = "") _
            Or (fldAM23 = "") And (fldPM23 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM24 <> fldPM24 Then
        ttfTempAM = fsmFieldParser(fldAM24.Value)
        ttfTempPM = fsmFieldParser(fldPM24.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM24 <> Null) And (fldPM24 = "") _
            Or (fldAM24 = "") And (fldPM24 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM25 <> fldPM25 Then
        ttfTempAM = fsmFieldParser(fldAM25.Value)
        ttfTempPM = fsmFieldParser(fldPM25.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
```

```
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM25 <> Null) And (fldPM25 = "") _
            Or (fldAM25 = "") And (fldPM25 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM26 <> fldPM26 Then
        ttfTempAM = fsmFieldParser(fldAM26.Value)
        ttfTempPM = fsmFieldParser(fldPM26.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM26 <> Null) And (fldPM26 = "") _
            Or (fldAM26 = "") And (fldPM26 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM27 <> fldPM27 Then
        ttfTempAM = fsmFieldParser(fldAM27.Value)
        ttfTempPM = fsmFieldParser(fldPM27.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
```

```
        bQ1Count = bQ1Count + 1
    If ((fldAM27 <> Null) And (fldPM27 = "") _
            Or (fldAM27 = "") And (fldPM27 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM28 <> fldPM28 Then
        ttfTempAM = fsmFieldParser(fldAM28.Value)
        ttfTempPM = fsmFieldParser(fldPM28.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM28 <> Null) And (fldPM28 = "") _
            Or (fldAM28 = "") And (fldPM28 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM31 <> fldPM31 Then
        ttfTempAM = fsmFieldParser(fldAM31.Value)
        ttfTempPM = fsmFieldParser(fldPM31.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
        If ((fldAM31 <> Null) And (fldPM31 = "") _
            Or (fldAM31 = "") And (fldPM31 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM32 <> fldPM32 Then
        ttfTempAM = fsmFieldParser(fldAM32.Value)
```

```
        ttfTempPM = fsmFieldParser(fldPM32.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM32 <> Null) And (fldPM32 = "") _
            Or (fldAM32 = "") And (fldPM32 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM33 <> fldPM33 Then
        ttfTempAM = fsmFieldParser(fldAM33.Value)
        ttfTempPM = fsmFieldParser(fldPM33.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM33 <> Null) And (fldPM33 = "") _
            Or (fldAM33 = "") And (fldPM33 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM34 <> fldPM34 Then
        ttfTempAM = fsmFieldParser(fldAM34.Value)
        ttfTempPM = fsmFieldParser(fldPM34.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
```

```
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM34 <> Null) And (fldPM34 = "") _
            Or (fldAM34 = "") And (fldPM34 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM35 <> fldPM35 Then
        ttfTempAM = fsmFieldParser(fldAM35.Value)
        ttfTempPM = fsmFieldParser(fldPM35.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM35 <> Null) And (fldPM35 = "") _
            Or (fldAM35 = "") And (fldPM35 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM36 <> fldPM36 Then
        ttfTempAM = fsmFieldParser(fldAM36.Value)
        ttfTempPM = fsmFieldParser(fldPM36.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
```

```
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM36 <> Null) And (fldPM36 = "") _
            Or (fldAM36 = "") And (fldPM36 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM37 <> fldPM37 Then
        ttfTempAM = fsmFieldParser(fldAM37.Value)
        ttfTempPM = fsmFieldParser(fldPM37.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM37 <> Null) And (fldPM37 = "") _
            Or (fldAM37 = "") And (fldPM37 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM38 <> fldPM38 Then
        ttfTempAM = fsmFieldParser(fldAM38.Value)
        ttfTempPM = fsmFieldParser(fldPM38.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM38 <> Null) And (fldPM38 = "") _
            Or (fldAM38 = "") And (fldPM38 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM41 <> fldPM41 Then
```

```
        ttfTempAM = fsmFieldParser(fldAM41.Value)
        ttfTempPM = fsmFieldParser(fldPM41.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
        If ((fldAM41 <> Null) And (fldPM41 = "") _
            Or (fldAM41 = "") And (fldPM41 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM42 <> fldPM42 Then
        ttfTempAM = fsmFieldParser(fldAM42.Value)
        ttfTempPM = fsmFieldParser(fldPM42.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM42 <> Null) And (fldPM42 = "") _
            Or (fldAM42 = "") And (fldPM42 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM43 <> fldPM43 Then
        ttfTempAM = fsmFieldParser(fldAM43.Value)
        ttfTempPM = fsmFieldParser(fldPM43.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
```

```
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM43 <> Null) And (fldPM43 = "") _
            Or (fldAM43 = "") And (fldPM43 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM44 <> fldPM44 Then
        ttfTempAM = fsmFieldParser(fldAM44.Value)
        ttfTempPM = fsmFieldParser(fldPM44.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM44 <> Null) And (fldPM44 = "") _
            Or (fldAM44 = "") And (fldPM44 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM45 <> fldPM45 Then
        ttfTempAM = fsmFieldParser(fldAM45.Value)
        ttfTempPM = fsmFieldParser(fldPM45.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
```

```
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM45 <> Null) And (fldPM45 = "") _
            Or (fldAM45 = "") And (fldPM45 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM46 <> fldPM46 Then
        ttfTempAM = fsmFieldParser(fldAM46.Value)
        ttfTempPM = fsmFieldParser(fldPM46.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM46 <> Null) And (fldPM46 = "") _
            Or (fldAM46 = "") And (fldPM46 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
    If fldAM47 <> fldPM47 Then
        ttfTempAM = fsmFieldParser(fldAM47.Value)
        ttfTempPM = fsmFieldParser(fldPM47.Value)
        If ttfTempAM.Distal <> ttfTempPM.Distal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
            bTSurface = bTSurface + 1
        End If
        If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
            bTSurface = bTSurface + 1
        End If
        bCountDiff = bCountDiff + 1
        bQ1Count = bQ1Count + 1
    If ((fldAM47 <> Null) And (fldPM47 = "") _
            Or (fldAM47 = "") And (fldPM47 <> Null)) Then
        bSpecCon = bSpecCon + 1
        End If
    End If
```

```
        If fldAM48 <> fldPM48 Then
            ttfTempAM = fsmFieldParser(fldAM48.Value)
            ttfTempPM = fsmFieldParser(fldPM48.Value)
            If ttfTempAM.Distal <> ttfTempPM.Distal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Lingual <> ttfTempPM.Lingual Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Mesial <> ttfTempPM.Mesial Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Occusal <> ttfTempPM.Occusal Then
                bTSurface = bTSurface + 1
            End If
            If ttfTempAM.Vestibular <> ttfTempPM.Vestibular Then
                bTSurface = bTSurface + 1
            End If
            bCountDiff = bCountDiff + 1
            bQ1Count = bQ1Count + 1
        If ((fldAM48 <> Null) And (fldPM48 = "") _
                Or (fldAM48 = "") And (fldPM48 <> Null)) Then
            bSpecCon = bSpecCon + 1
            End If
        End If

        'Place victim details into TDTempArr
        If bCountDiff <> 0 Then
            With TDiff
                .strServiceNumber = fldAMsvcno
                .bToothSurface = bTSurface
                .b1QuadrantDiff = bQ1Count
                .b2QuadrantDiff = bQ2Count
                .b3QuadrantDiff = bQ3Count
                .b4QuadrantDiff = bQ4Count
                .bSpecialConsid = bSpecCon
                .bTotalDifferences = bCountDiff
            End With
            TDTempArr.arr_DynTDifference(iCtr) = TDiff
            iCtr = iCtr + 1
        End If
        rstAM.MoveNext
    Loop
    rstPM.MoveNext
Loop
CountDifferences = TDTempArr
End Function
'**********************************************************************
'**********************************************************************


Function fsmFieldParser(strParse As String) As TToothFace
'Author: Nikolaos Vogiatzis BSc(Ma & Comp Sc),
'        MBA(Technology Management) in progress
'Serial: 9705231601
'Special Thanks:
'   Special thanks to Mr Barry Dwyer, Senior Lecturer
'                    The University of Adelaide
```

```
'   For his suggestion that a Finite State Machine should
'   be used for this part of the problem
'Purpose:
'   To parse the value in a AM/PM Desc field, and return
'   the material found on each surface
'Development History:
'*********************************************************************
'   V1.0.0. 23th of May, 1997.  Test function:
'   The way in which we will parse the tooth surface description is:
'   1) Read in each character into a character array
'   2) Once whitespace is encountered, the previous character set
'is saved into a string variable
'   3) The next characters up to but not including a sentinel value is
'analysed and the value from the previous string variable is placed
'in each appropriate record position.
'   4) It then checks to see if there are any more charactes after the
'sentinel,if not, then it stops, else it starts at position 1 again.

'*********************************************************************

'   V2.0.0. 02nd of June, 1997.  FSM Model:
'   Breaks up each value in the desc field and returns a record.
'   Uses a Finite State Machine to parse the string, hence the
'   fsm prefix.
'*********************************************************************
'Method:
'   The technique that will be employed in this function is called
'   a FINITE STATE MACHINE.
'
'   This technique considers each element of the parsable input as
'   a series of finite and distinct states.
'
'   In the case of the field being parsed, we are interested in
'   separating from the field, the material, and the surfaces it
'   inhabits.
'
'*********************************************************************
'Definitions:
'   sp ::= space
'   M|D|L|V|O ::= surface codes
'   ; ::= terminating sentinel
'   a-z A-Z \{M|D|L|V|O} ::= characters that form the material
'                            less special characters
'
'*********************************************************************
'FSM Table Definitions:
'                   *******************************
'                   |  1  |  2  |  3  |  4  |  5  | Current State
'                   *******************************
'                sp |  1  |  3  |  3  |  -  |  -  |
'                   *******************************
'             MDLVO |  2  |  2  |  4  |  4  |  -  |
'                   *******************************
'                 ; |  -  |  -  |  -  |  1  |  -  |
'                   *******************************
'   a-z A-Z \ MDLVO |  2  |  2  |  -  |  -  |  -  |
'                   *******************************
'       end of line |  -  |  -  |  -  |  -  | eol |
```

```
'                    *******************************
'
'*********************************************************************
'General Comment:
'   Although in modern programming, the use of goto statements and
'   labels are not commonly accepted, the method described above
'   i.e. Finite State Machine, lends itself to this older style
'   of programme code.
'   It is the opinion of this programmer that less extenuating
'   circumstances, goto/label programming should not be used.
'
'*********************************************************************
'*********************************************************************


'Define variables and constants as required
Const strNull As String = ""
Const strWhiteSpace As String = " "
Const strErrorWarning As String = "System Error: Please report the
following number: "
Const iInit As Integer = 1
Const iStep As Integer = 1


Dim strTemp As String
Dim ttfResult As TToothFace
Dim strMaterial As String * 20
Dim arbStringLen    '"arb" represents arbitrary type
Dim iCtr As Integer
Dim bCheck As Byte
Dim iRes As Integer

'Start up routines
arbStringLen = Len(strParse)
strTemp = strNull
strMaterial = strNull
iCtr = iInit
bCheck = 0
With ttfResult
    .Distal = strNull
    .Lingual = strNull
    .Mesial = strNull
    .Occusal = strNull
    .Vestibular = strNull
End With


'Start the Finite State Machine
Do While True
StateOne:
    'Stay in State One until non-space character met
    If Mid(strParse, iCtr, iStep) = ";" Then
        bCheck = 1
        GoTo FSM_Err
    End If
    Do Until Mid(strParse, iCtr, iStep) <> strWhiteSpace
        'Ignore whitespace by counting over it
        iCtr = iCtr + 1
```

```
    Loop
    GoTo StateTwo

StateTwo:
    'Stay in State Two until space character met
    If Mid(strParse, iCtr, iStep) = ";" Then
        bCheck = 2
        GoTo FSM_Err
    End If
    Do Until Mid(strParse, iCtr, iStep) = strWhiteSpace
        strTemp = strTemp + Mid(strParse, iCtr, iStep)
        iCtr = iCtr + 1
    Loop
    strMaterial = strTemp
    GoTo StateThree

StateThree:
    'Stay in State Three until no more whitespace met
    If Mid(strParse, iCtr, iStep) <> strWhiteSpace Then
        bCheck = 3
        GoTo FSM_Err
    End If
    Do Until Mid(strParse, iCtr, iStep) <> strWhiteSpace
       'Ignore whitespace by counting over it
       iCtr = iCtr + 1
    Loop
     GoTo StateFour

StateFour:
    'Stay in State Four until the next character after the _
    semi-colon is a null character
    If Mid(strParse, iCtr, iStep) = ";" Then
        bCheck = 4
        GoTo FSM_Err
    End If
    Do
        With ttfResult
            Select Case Mid(strParse, iCtr, iStep)
            Case "M"
             If .Mesial <> strNull Then
                GoTo FSM_Err
             Else
                .Mesial = strMaterial
             End If
            Case "L"
             If .Lingual <> strNull Then
                GoTo FSM_Err
             Else
                .Lingual = strMaterial
             End If
            Case "V"
             If .Vestibular <> strNull Then
                GoTo FSM_Err
             Else
                .Vestibular = strMaterial
             End If
            Case "D"
             If .Distal <> strNull Then
```

```
                    GoTo FSM_Err
                 Else
                    .Distal = strMaterial
                 End If
                Case "O"
                 If .Occusal <> strNull Then
                    GoTo FSM_Err
                 Else
                    .Occusal = strMaterial
                 End If
                Case Else
                 GoTo FSM_Err
                End Select
            End With
            iCtr = iCtr + 1
        Loop Until Mid(strParse, iCtr, iStep) = ";"
        GoTo StateFive
StateFive:
        iCtr = iCtr + 1
        If Mid(strParse, iCtr, iStep) = strNull Then
            Exit Do
        Else
            strMaterial = strNull
            strTemp = strNull
            GoTo StateOne
        End If
Loop
fsmFieldParser = ttfResult
GoTo Function_End

FSM_Err:
    Select Case bCheck
        Case 1
            iRes = MsgBox(strErrorWarning + CStr(bCheck), vbOKOnly,
"System Warning")
        Case 2
            iRes = MsgBox(strErrorWarning + CStr(bCheck), vbOKOnly,
"System Warning")
        Case 3
            iRes = MsgBox(strErrorWarning + CStr(bCheck), vbOKOnly,
"System Warning")
        Case 4
            iRes = MsgBox(strErrorWarning + CStr(bCheck), vbOKOnly,
"System Warning")
        Case Else
            MsgBox ("System Failure::Else")
    End Select
Function_End:
End Function
```

7.6 QUESTIONNAIRE FOR EVALUATION OF THE EFFECTIVENESS OF USER INTERFACE FOR ODONTID PROFESSIONAL©

The following questionnaire consists of 64 questions.

A. Details relating to the user's experience.

This questionnaire is confidential.

Please do not include your name.

1.	Position within Dental Service.	DO	DSA/DN	DT
		1	2	3
2.	Age (year).	(24-35)	(36-45)	(46-55)
		1	2	3
3.	Number of years in service (year).	(1-10)	(11-20)	(20-30)
		1	2	3
4.	Previous experience with the use of computers.		Yes	No
5.	Previous training with the use of computers.		Yes	No

		Strongly disagree				Strongly agree
10.	The terminology related to the task domain closely	1	2	3	4	5
11.	The computer-related terms used were appropriate	1	2	3	4	5
12.	The terms on the screen were precise	1	2	3	4	5
13.	The amount of feedback was always user-controlled	1	2	3	4	5
14.	The terminology was consistent	1	2	3	4	5
15.	The task related terminology was consistent	1	2	3	4	5
16.	The instruction describing tasks were clear	1	2	3	4	5
17.	The instructions for commands or choices were clear	1	2	3	4	5
18.	Instructions for correcting errors were clear	1	2	3	4	5
19.	Instructions for getting more help were clear	1	2	3	4	5
20.	Instructions were always consistent	1	2	3	4	5
		Strongly disagree				Strongly agree

		Strongly disagree				Strongly agree
21.	Operations were closely related to tasks	1	2	3	4	5
22.	Information feedback was always appropriate	1	2	3	4	5
23.	Links between operation and results were clear	1	2	3	4	5
24.	Display layouts always simplified tasks	1	2	3	4	5
25.	Sequence of displays were clear	1	2	3	4	5
26.	Next screen was in a predictable sequence	1	2	3	4	5
27.	Going back to previous display was easy	1	2	3	4	5
28.	Pace of Interaction was fast enough	1	2	3	4	5
29.	Response time for most operations were fast enough	1	2	3	4	5
30.	Error messages appeared fast enough	1	2	3	4	5
31.	Error message was always helpful	1	2	3	4	5
		Strongly disagree				Strongly agree

		Strongly disagree				Strongly agree
32.	Error messages clarified the problem	1	2	3	4	5
33.	Error messages indicated actions to be taken					
34.	Error messages were always specific	1	2	3	4	5
35.	Error messages were pleasing	1	2	3	4	5
36.	Error correction was clear	1	2	3	4	5
37.	Going back to change values was simple	1	2	3	4	5
38.	Undoing operations was simp	1	2	3	4	5
39.	Online help was clear	1	2	3	4	5
40.	Content of online help was clear	1	2	3	4	5
41.	Learning the operation was easy	1	2	3	4	5
42.	Getting started was easy	1	2	3	4	5
43.	Learning more features was easy	1	2	3	4	5
44.	Relearning after intermittent use was easy	1	2	3	4	5
		Strongly disagree				Strongly agree

		Strongly disagree				Strongly agree
45.	Tutorials were clear	1	2	3	4	5
46.	Information to complete tasks was visible	1	2	3	4	5
47.	Information patterns were recognisable	1	2	3	4	5
48.	Supplemental reference materials were clear	1	2	3	4	5
49.	Exploration of features was encouraged	1	2	3	4	5
50.	Meaningful prompts were provided	1	2	3	4	5
51.	Learning new features was easy	1	2	3	4	5
52.	Displays were orderly	1	2	3	4	5
53.	Abbreviations were clear	1	2	3	4	5
		Strongly disagree				Strongly agree

C. Please circle the appropriate response according to your general findings

54.	Any missing stages?	yes	no
55.	Data were never duplicated?	yes	no
56.	Any poorly designed screens?	yes	no
57.	Facilities adequate?	yes	no
58.	Quick performance?	yes	no
59.	Was communication adequate?	yes	no
60.	Easy to control?	Yes	no

D. Any comments

61. Aspects of screen display which could be improved/modified? …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………
62. Which aspects of OdontID Professional© have you found to be of assistance in your daily clinical work? …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………

63. Have any aspects of OdontID Professional© been a restriction on your daily work load? ....
64. Other comments. ....

REFERENCES

REFERENCES

1. Keiser-Nielsen S. Person identification by means of teeth. Bristol: John Wright and Sons, 1980:V.

2. Buchner A. The identification of human remains. Int Dent J 1985;35(4):307-311.

3. Harvey W. Dental identification and forensic odontology. London: Hanry Kimpton. 1976:188.

4. Faki B. Forensic Odontology identification through dental characteristic and its application to Malaysian Armed Forces. Personal communication. 1993.

5. Cleland JB. Teeth and bites in history, literature, forensic medicine and otherwise. Aust Dent J 1944;48(3):107-123.

6. Brown KA. Historical review: The identification of Linda Agostini. The significant of dental evidence in Albury ' Pyjama Girl' Case. Am J Forensic Med Pathol 1982;3(2):131-141.

7. Brown KA. The identification of Linda Agostini. The significant of dental evidence in Albury ' Pyjama Girl' case. A case report. Forensic Sci Int 1982;20:81-86.

8. Keiser-Nielsen S. Forensic Odontology: It's Scope and History. In Ian R. Hill ed. Bicester OXON: The Old Swan, 1984:69-75.

9. Pert DI. Dental aspect of the Mt. Erebus disaster. NZ Dent J 1980;76(346):187-193.

10. Brown KA. Mass disaster investigation and identification: Dental identification of unknown bodies. Ann Acad Med Singapore 1986;13(1):3-7.

11. The Star (Malaysian edition) 18th March 1997. 11 military personnel killed in Two Royal Malaysian Air Force Helicopter crash at Sepadan Island, Sabah. Personal communication. 1997.

12. Shroff FR. Forensic odontology for the general practitioner. Aust Dent J 1973;18(5):298-303.

13. Brownlie AR. How often are expert right in-crime investigation, art or science? Edinburgh: Scottish Academic Press, 1984.

14. Brown KA. Forensic aspects of community dentistry. Ann Acad Med Singapore 1986;15(3):414-417.

15. Taylor DV. The Law and the dentist. Br Dent J 1963; 114(may):189-393.

16. Tierney K. Contracts and dentistry. In Kersey RR. edn. Symposium of legal considerations. Dent Clin North Am. Philadelphia: WB Sounders, 1982;26(2):281-286.

17. LaRene Deday NC. The dentist accused of criminal misconduct. In Kersey RR. edn. Symposium of legal considerations. Dent Clin North Am. Philadelphia: WB Sounders, 1982;26(2):401-404.

18. Sills HH. What is the law? In Kersey RR edn. Symposium of legal considerations. Dent Clin North Am. Philadelphia: WB Sounders, 1982;26(2):253-259.

19. Bechstead JW, Rawson RD, Giles SW. Review of bite mark evidence. J Am Dent Assoc 1979;99(1):69-74.

20. Luntz LL, Luntz P. Handbook for dental identification. Techniques in forensic dentistry. Philadelphia: JB. Lippincott Co, 1973:149-150.

21. Vale GL. Bitemark evidence in investigation of crime. Calif Dent Assoc J 1986;14(march):36-42.

22. Sopher IM. Forensic Dentistry. Springfield, Illinois: Charles C Thomas, 1976:30-136.

23. Cameron JM, Sims BG. Forensic Dentistry. Edinburgh: Churchill-Livingstone, 1974:1-4.

24. Gustafson G. Forensic Odontology. London: Staples Press, 1966:118-140.

25. Keiser-Nielsen S. Dental identification in mass disaster. J Dent Res 1963;42(1):303-311.

26. Knott NJ. Identification by the teeth of casualties in the Aberfan disaster. Br Dent J 1967;122(3):144-145.

27. Jerman AC. Military requirement for dental identification of human remain. Mil Med 1981;146(4):262-265.

28. Cattone JA. Dental Identification. In: Cattone JA, Standish SM. Eds. Outline of forensic dentistry. Chicago: Years Book Medical Publishers, 1982:73-87.

29. Sims BG. Forensic Dentistry. In: Deutch Y. Ed. Science Against Criminal. London: Marshall Carendish Book Limited, 1982:87-101.

30. Sims BG. Homocide and the dentist. Med Leg J 1980;48(1): 25-47.

31. Sopher IM. Forensic Dentistry. Springfield, Illinois: Charles C Thomas, 1976:47-56.

32. Brown KA. International communication and cooperation in forensic odontology. J Forensic Odonto-Stomatology 1988; 6(1):29-34.

33. Identification Disaster Victim. FBI Law Bulletin 1970, revised 1979;47:98-104.

34. Van Wyk CW, Kemp VD, Bukofzer H. Role of dental identification in the Windhoek air crash. Med Leg J 1969;37 (2):79-84.

35. Stevens PJ, Tarlton SW. Identification of mass casualties: Experience in four civil air disasters. Med Sci Law 1963;3(2): 154-168.

36. Rothwell BR, Haglund W, Morton Jr TH. Dental identification in serial homicide: The Green River murder . J Am Dent Assoc 1989;119(3):373-379.

37. Farrell WL. Forensic identification of burn victims. J Am Dent Assoc 1979;99(1):51-56.

38. Haglund WD, Reay DT, Tepper SL. Identification of decomposed human remains by deoxyribonucleic acid (DNA) profiling. J Forensic Sci 1991;35(3):724.

39. Sognnaes RF. Forensic Stomatology. N Engl J Med 1977;296 (2):79-85.

40. Waggoner WF, Dolenuck RP. Micro disk dental identification systems. J Okalahoma Dent Assoc 1986;76:27.

41. Levine LL. Forensic Odontology: Identification by dental means. Aust Dent J 1977;22(6):481-487.

42. Haines DH. Racial characteristics in forensic dentistry. Med Sci Law 1972;12(2):131-138.

43. Mertz CA. Dental Identification. In Reinhardt RW. edn. Forensic dentistry: Legal obligations and method of identification for the practitioner. Dent Clinic North Am. Philadelphia: WB Saunders, 1977;21(1):46-56.

44. Vale GL. The role of forensic dentist in mass disasters. In Reinhardt RW. edn. Forensic dentistry: Legal obligations and method of identification for the practitioner. Dent Clinic North Am. Philadelphia: WB Saunders, 1977;21(1):123-125.

45. Keiser-Nielsen S. There are no two cases alike. Int Dent J 1975;25(3):191-197.

46. Keiser-Nielsen S. There are no two cases alike. Int J Forensic Dent 1977;4(1):22.

47. Furness J, Moore G, Waud E. The identification of victims of mass disaster and also the identification of individual remains. Br Dent J 1969;127(10):501-504.

48. Haines DH. Dental identification in Rijeka air disaster. J Forensic sci 1972;1:313-321.

49. Fisher-Russell S. Techniques of identification applied to 81 extremely fragmented aircraft fatalities. J Forensic Sci 1965;10: 121-135.

50. Brannon LS. Forensic Odontology: an application for the army dentist. Mil Med 1983;148(12):655-658.

51. Butler OH. Forensic Odontology: Report of British Dental Association, winter scientific meeting December 1970. Br Dent J 1971;130(4):164.

52. Sognness RF. Forensic Stomatology. N Engl J Med 1977; 296:79-85.

53. Simpson K. Dental evidence in the recostruction of crime. Br Dent J 1951a;91(9):229-238.

54. Dorion RBJ. Disaster big and small. Calif Dent Assoc J 1990;56(7):593-598.

55. Clark DH. An anlysis of the value of forensic odontology in ten mass disaster. Int Dent J 1994;44(3):241-250.

56. Sopher IM. Forensic Dentistry. Springfield, Illinois: Charles C Thomas, 1976:60-63.

57. Sopher IM. The dentist, the forensic pathologist and the identification of human remain. J Am Dent Assoc 1972;85(6): 1324-1329.

58. Levine S. Forensic odontology-identification by dental means. Aust Dent J 1977;22(6):481-487.

59. Bang G. Report of importance in dental identification: Five Case Reports. Forensic Sci Int 1972;1(1):91-102.

60. Keiser-Nielsen S. Person identification by means of teeth. Bristol: John Wright and Sons Ltd, 1980:6-8.

61. Luntz LL, Luntz P. Handbook for dental identification. techniques in forensic dentistry. Philadelphia: JB. Lippincott Co, 1973:42-72.

62. Sopher IM. Forensic dentistry. Springfield, Illinois: Charles C Thomas, 1976:40.

63. Gustafson G. Microscopic examination of teeth as a means of identification in forensic medicine. J Am Dent Assoc 1947;35 (10):720-726.

64. Miles AEW. Forensic Odontology: Report of British dental association, winter scientific meeting, December 1970. Br Dent J 1971;130(4):161-168.

65. Shroff FR. Identification by teeth: A possible source of error. Br Dent J 1956;107(7):178-180.

66. Dalitz GD. Age determination of adult human remains by teeth examination. J Forensic Sci 1962;3:11-21.

67. Gustafson G. Age determination on teeth. J Am Dent Assoc 1950;41(1):45-54.

68. Gustafson G. Forensic Odontology. London: Staples Press, 1966:103-116.

69. Sopher IM. Forensic Dentistry. Springfield, Illinois: Charles C Thomas, 1976:105.

70. Luntz LL, Luntz P. Handbook for dental identification. techniques in forensic dentistry. Philadelphia: JB. Lippincott Co, 1973:135.

71. Sopher IM. Forensic Dentistry. Springfield, Illinois: Charles C Thomas, 1976:3-4.

72. Scott JH, Symons NBB. Introduction to dental anatomy. Edinburgh and London: E & S Livingstone Ltd, 1961:111.

73. Keiser-Nielsen S. Geographic factor in forensic odontology. Int Dent J 1965;15(3):343-347.

74. Lasker CW, Lee MC. Racial traits in human teeth. J Forensic Sci 1957;2:401.

75. Scott JH, Symons NBB. Introduction to dental anatomy. Edinburgh and London: E & S Livingstone Ltd, 1961:38.

76. Atchison J. Some racial differences in human skull and jaws. Br Dent J 1964;116(Jan):25.

77. Keiser-Nielsen S. Person identification by means of teeth. Bristol: John Wright and Sons, 1980:40-42.

78. Luntz LL, Luntz P. Handbook for dental identification. Philadelphia: JB Lippincott, 1973:56-68.

79. Daily JC. The identification of fragmented Vietnam war remains utilising healing extraction site. J Forensic Sci 1991; 36(1):264.

80. Daily JC, Webb JE Jr. Forensic odontology task force organisation. Mil Med 1988;153(3):133-137.

81. Brown KA. The role of forensic odontology in the Azaria Chamberlain case. The Dent Annual 1986;13(1):42-54.

82. Sopher IM. Forensic Dentistry. Springfield, Illinois: Charles C Thomas, 1976:63.

83. Sognness RF, Rawson RD, Gratt BM, Nguyen NBT. Computer comparison of bitemark patterns in identical twins. J Am Dent Assoc 1982;105(3):449-451.

84. Furness J. Forensic Odontology: Report of British dental association, winter scientific meeting, December 1970. Br Dent J 1971;130(4):161.

85. Keiser-Nielsen S. Dental identification: Certainty V probability. J Forensic Sci 1956;42:303-311.

86. Keiser-Nielsen S. Person identification by means of teeth. Bristol: John Wright and Sons, 1980:61-66.

87. Rawson RD, Ommen RK, Kinard G, Johnson J, Tfantis A. "Statistic evidence for the individuality of the human dentition. J Forensic Sci 1984;29(1):245-253.

88. Brown T, Townsend GL, Richard LC, Travan GR. A study of dentofacial morphology in South Australia twins. Aust Dent J 1987;32(2):81-90.

89. Humble BH. Identification by means of teeth. Br Dent J 1933;54(10):528-536.

90. Cleland JB. Dental identification in the Ruxton case. Aust Dent J 1944;48:107.

91. Peterson KB, Kogan SL. Dental identification in the Woodbridge disaster. J Can Dent Assoc 1971;37(7):275-279.

92. Haines DH. Dental identification in Stockport air disaster. Br Dent J 1967;123(7):336-338.

93. Clark DH. Dental identification problems in the Abu Dhabi air accident. Am J Forensic Med Pathol 1986;7(4):317-321.

94. Sims BG. Some aspect of the role of the dentist in forensic odontology. Br Med J 1977;4:85-89.

95. Grant EA, Prendergast WK, White EA. Dental identification in the Noronic disaster. J Can Dent Assoc 1952;18(1):1-18.

96. Eisele J, O'Halloran R, Reay D. Death during the May 18, 1980 eruption of Mouth St. Helens. N Engl J Med 1981; 305:931-936.

97. Jakush J. Forensic dentistry. J Am Dent Assoc 1989; 119:355-368.

98. Smith GA, Palian CW. Dental Identification and the P-3 crash in Hawaii. Mil Med 1985;150(2):59-66.

99. Cattone JA, Standish, SM. Eds. Outline of Forensic dentistry. Chicago: Years Book Publishers, 1982:113-121.

100. Hill IR. Inconsistency in dental evidence. Med Sci Law 1988; 28(3):212-216.

101. Siegel R, Sperber ND, Trieglaff BS. Identification trough the computerization of dental record. J Forensic Sci 1977; 22:434-442.

102. Ireland EJ, Carr RF. Can dentist recognise their own work? Am J Forensic Med Pathol 1990;11:233.

103. Haglund WD, Reay DT, Snow CC. Identification of serial homicide victims in the "Green River Murder" investigation. J Forensic Sci 1987;32(6):1666-1675.

104. Hall WM. Comment od system of tooth designation. Dental Survey 1950;26(4):382.

105. Olson G. Record simplifier. Dental Survey 1950;26(4):376.

106. Frykholm KO, Lysell L. Different system for the recording of teeth and tooth surface. Int Dent J 1962;12:194-207.

107. Beale DR. The importance of dental records for identification. NZ Dent J 1991;87(389):84-87.

108. Symbolic system revealed as most popular method of tooth designation. Continuing study of professional opinion since 1938. Dental Survey 1950;26(4):510-513.

109. Mc Call JO. ...... Symbolic system advantages. Dental Survey 1950;26(4):384.

110. Coppock DA. Keeping up-to-date with dental notation. Br Dent J 1986:166(4):108.

111. Rault CV. ....about the Navy System. Dental Survey 1950;26 (4):382-384.

112. Clark DH. Dental record interpretation. In: Clark DH. Ed. Practical forensic odontology. Oxford: Butterworth-Heinemann, 1992:101-125.

113. Elderton RJ. Keeping up-to-date with tooth notation. Br Dent J 1989;160(2):55-56.

114. Goodman P. A Universal System for identifying permenent and primary teeth. J Dentistry for Children 1967;34:312-315.

115. Sandham JA. The FDI Two-Digit System of designation teeth. Int Dent J 1983;33(4):390-392.

116. Mertz CA. Dental Identification. In Reinhardt RW. edn. Forensic dentistry: Legal obligations and method of identification for the practitioner. Dent Clinic North Am. Philadelphia: WB Saunders, 1977;21:57-59.

117. Palmer C. Palmer's dental notation. Dent Cosmos 1891; 33(3): 194-198.

118. Paquette NJ. Why can't dentists all use same system of tooth designation? Dental Survey 1950;26(4):52-54.

119. Armed Forces Medical, Administration and Technical Instruction (AFMATI). Personal communication. 1976.

120. Manual on disaster victim identification. International Police Organitation. 1984.

121. Mertz CA. Dental Identification. In Reinhardt RW. edn. Forensic dentistry: Legal obligations and method of identification for the practitioner. Dent Clinic North Am. Philadelphia: WB Saunders, 1977;21:49-53.

122. Clark DH. Dental record interpretation. In: Clark DH. Ed. Practical forensic odontology. Oxford: Butterworth-Heinemann, 1992:114-115.

123. Imobersteg C. The falsification of an odontogram. Forensic Sci Int 1982;48(2):221.

124. FDI. Fifty-eight annual session. News and comment. NZ Dent J 1971;67(307):41.

125. FDI. Chronicale of the 58th annual session. Bucharest, Romania, 1970. Int Dent J 1971;21(1):104-106.

126. Ahlberg JE. We must get the numbers right. Federation Dentaire Internationale news letter 1988;158:8-9.

127. Barr EA. Forensic dentistry. Br Dent J 1967;122(3):84.

128. Keiser-Nielsen S. Historical cases. In Hill IR, Keiser-Nielsen, Vermylen Y, Free A, Valck de E, Tormans E, eds. Forensic Odontology: It's Scope and History. Solihull: Alan Cliff Associates, 1984.38-40.

129. Kessler HP, Pemble CW. Forensic dental identification of casualties during Operation Desert Storm. Mil Med J 1993; 158(6):359-362.

130. Haron MI, Brown KA, Taylor JA. Identification of the Malaysian battle casualties in the U.N. Peace Keeping Forces in Somalia, 1995. *Abstracts*, the 14th meeting of the International Association of Forensic Science. Tokyo. 1996.

131. Hill, I.R. Dental identification in a light aircraft accident. Med Sci Law 1979;19(2):82-85.

132. Hill IR. Dental record of military personnel. Int Dent J 1985; 35: 312-315.

133. Cohen MC, Schreoeder DC, Cecil JC. Computer-Assisted forensic identification of military personnel. Mil Med 1983; 148 (2):153-156.

134. Pierce L, Lindsay J, Lautenschlager EP, Smith ES, Harcourt JK. Developing a forensic dental code and programme. Aust Dent J 1982;27(1):16-21.

135. Gillespie TH, Brannon RB, Grayson FW, Gardner JD. Dental identification of remains from the 23 October 1983 bombing of the U.S. Marine Headquarters, Beirut, Lebanon. Mil Med 1985;150(12):635-639.

136. Alexander RE. Charting accuracy in navy dental records. Mil Med 1991;156(1):8-10.

137. Haines DH. Identification in mass disasters from dental prostheses. Int J Forensic Dent 1973;1(1):11-15.

138. Davis MJ. The missing child: what can we do? New York Dent J 1986;52:20.

139. Meter C. Micro Information Disc. J Ohio Dent Assoc 1985; 59:10.

140. Sperber N. Dental micro disks: Gimmick or important forensic development? Calif Dent Assoc J 1986;14:33-35.

141. Wilson DF, Kolbinson D. The heat resistance of a data-encoded ceramic microchip identification system. Am J Forensic Med Pathol 1983;4(3):209-215.

142. Carlsen A. "Taenderne som Identification" ("Teeth as a means of identification"), Tandlaegbladet. 1931; 35: 411 (cited by G. Gustafson in Forensic Odontology. London: Staples Press, 1976:76-79.)

143. Kruger-Monsen A. "Merking av plateproteser for identifasjon" ("Marking of denture for identification"), Tannlaegeforen Tid. 1962; 72: 226 (cited by G. Gustafson in Forensic Odontology. London: Staples Press, 1976:76-79.)

144. Jerman AC. Denture Identification. J Am Dent Assoc 1970; 80(6):1358-1359.

145. Lose FM. Denture identification. J Prosth Dent 1958;8(6): 940-941.

146. Woodward JD. Denture marking for identification. J Am Dent Assoc 1979;99:59-60.

147. Davis DJ. "Invisible" denture identification: A forensic aid. J Prosth Dent 1982;48(2):221.

148. Mayclin TJ. US. Patent No. 4,027,391 US. Patent Office, Washington, DC. 1981. (cited by Hansen RW in Intraoral micro-identification discs. J Forensic Odonto-Stomatology 1991;9 (2):76-91.

149. Samis PL. Systems of dental identification. Can Soc Forensic J 1975;8:77-86.

150. Muhlemann HR, Steiner E, Brandestin M. Identification of mass disaster: The Swiss Identification System. J Forensic Sci 1979;24(1):173-181.

151. Ellgren RW. U.S. Patent No. 4,557,693 U.S. Patent Office, Washington, DC. 1983. (cited by Hansen RW in Intraoral micro-identification discs. J Forensic Odonto-Stomology 1991;9 (2):76-91.)

152. Hansen RW. Intraoral micro-identification discs. J Forensic Odonto-Stomatology 1991;9(2):76-91.

153. Wilson DF, Kolbinson D. The heat resistance of a ceramic microchip identification device. Aust Dent J 1982;27:219-223.

154. Gladfelter IA, Smith BE. An evaluation of microdisks for dental identification. J Prosth Dent 1989;62:352-355.

155. Lorton L, Langley WH. Decision making concepts in post-mortem identification. J Forensic Sci 1986;31(1):190-196.

156. Scholle RH. The problem with John Doe et al. J Am Dent Assoc 1985;110(6):1022.

157. Welty LG, Glasgow RR. A system of dental Identification. J Am Dent Assoc 1946;33(11):714-720.

158. Woolridge ED. Forensic dentistry. In Eckert, W.G. Ed. Introduction to forensic sciences. St. Louis: Mosby, 1980: 114-117.

159. Keiser-Nielsen S. Digitalization of dental recording. Forensic Sci Int 1982;20:153-161.

160. Stelt Van Der PF. The micro computer in the dental office: A new dignostic aid. Int Dent J 1985;35:103-108.

161. Wolter CA. Computer-aided in-operatory examinations. Can Dent Assoc J 1986;14:80-81.

162. Barsley RE, Carr RF, Cottone JA, Cuminale JA. Identification via dental remains: Pan American flight 759. J Forensic Sci 1985;30:128.

163. Lorton L, Langley WH. Design and use of a computer-assisted post-mortem identification system. J Forensic Sci 1986; 31(3): 972-981.

164. Sopher IM. Dental identification of aircraft accident fatalities. J Forensic Sci 1973;18:356.

165. Dr. Do-Little For Windows 95 and NT. Personal communication. 1995.

166. A.T.S.™ Dental System. Personal communication. 1995.

167. ToothPics™ Patient Management System. Personal communication. 1991.

168. DentalMac Practice Management System. Personal communication. 1995.

169. MacSpecialist II Management Accounting Package. Personal communication. 1995.

170. ULTIMA For Dentists. Personal communication. 1995.

171. HI-TECH Dental Programme. Personal communication. 1995.

172. Dentrix Practice Management System. Personal communication. 1995.

173. Rada RE. Computerising patient records: Organising the dental offices of the future. Dental Abstracts 1996;41(1):25.

174. DentalByte™. Personal communication. 1996.

175. Lorton L, Cornwell K. "Computer used in mass disaster identification" Computer use in forensic dentistry. In Averill DC. edn. Manual of forensic odontology. Colorado Spring: American Academy of Forensic Science, 1991:192.

176. Rotzscher K. The origins and development of FDI, INTERPOL, and IOFOS: International co-operation in identification. J Forensic Odonto-stomatology 1992;10(2):58-64.

177. Morlang WM, Siegel RS. Mass disaster management. In Cottone JA, Standish SM. Eds. Outline of forensic dentistry. Chicago, IL: Year Book Medical Publishers, 1982:93-4.

178. Baker BR. History of forensic dentistry. In Cottone JA, Standish SM. Eds. Outline of forensic dentistry. Chicago and London: Year Book Medical Publishers, 1982:20-27.

179. Morlang WM, Wright IS. Lessons from Big Thompson Canyon. Gen Dent 1977;26:36-9.

180. Kogan SL, Petersen KB, Locke JW, Ball RG. A Computerised aided to dental identification in mass disaster. J Forensic Sci 1974;3(2):151-162.

181. Cirigliano L. Disaster! Crash victims identification by forensic dentistry. Calif Dent Assoc J 1978;6(12):29-35.

182. Hagen M, Endris R, Wallmeier D. The COMPUTER-QUADRANT-METHOD. *Abstracts,* the 12th meeting of International Association of Forensic Science. Adelaide. 1990.

183. Hagen M, Strack S. The COMPUTER-QUADRANT-METHOD running on a PC. In: Jacob B, Bonte W. Eds. Advance in forensic sciences. Vol 7. Forensic odontology & anthropology. Berlin: Koster, 1995:247-249.

184. Solheim T, Ronning S, Hars B, Sundnes PK. A new system for computer aided dental identification in mass disasters. Forensic Sci Int 1982;20(2):127-131.

185. Dahl JE, Solheim T. Computer aided dental identification: Experience from the oil rig "Alexander L. Kielland" disaster. Personal communication. 1980.

186. Keiser-Nielsen S. A six digit code for computer-aided dental identification. Forensic Sci Int 1983;21:85.

187. Haines DH. Provisional dental classification in a mass disaster. Med Sci Law 1971;11:85-87.

188. Sakshaug O. Microcomputers in dental identification. Personal communication. 1980.

189. Sakshaug O. A Portable computers in mass disaster identification – A program based upon INTERPOL's Victims Identification Form. *Abstracts*, the 11th meeting of the International Association of Forensic Science. Vancouver, Canada, 1987. Special Edition. J Canad Soc Forensic Sci 1987;20(3):182

190. Lorton L. Forensic Dentistry. J Am Dent Assoc 1988;119 (5):356-368.

191. Dailey JC. Computer-Assisted identification of Vietnam war dental remains. Mil Med J 1987;152(4):179-186.

192. Dailey JC. "Computer Assisted identification of Vietnam remains"-Computer use in forensic dentistry. In Averill DC. edn. Manual of forensic odontology. Colorado Spring: American Academy of Forensic Science, 1991:223-229.

193. Dailey JC. Computer assisted identification of Vietnam war remains-Computer aided forensic odontology. In Bowers LM, Bell GL. eds. Manual of forensic odontology. Colorado Spring: American Society of Forensic Science, 1995:227-231.

194. Lorton L, Rethman M, Friedman RB. The Computer-Assisted Post-mortem Identification (CAPMI) System: A computer-based identification program. J Forensic Sci 1988;33(4):977-984.

195. Lorton L, Rethman M, Friedman RB. The Computer-Assisted Post-mortem Identification (CAPMI) System: Shorting algorithm improvements. J Forensic Sci 1989;34(4):996-1002.

196. Friedman RB, Cornwell KA, Lorton L. Dental characteristic of a large military population useful for identification. J Forensic Sci 1989;34(6):1357-1364.

197. Hashimoto M, Nakano Y, Suzuki K. A coding system for a computer aided dental identification based on the " Canobrain Programme". Ann Acad Med Singapore 1984;13(1):20-24.

198. Brown KA. Dental identification of unknown bodies. Ann Acad Med Singapore 1984;13(1):3-7.

199. Brown KA, Elliott TR, Hashimoto M. "OdontID"- A computer program for dental identification. Personal communication. 1985.

200. Brown KA, Elliott TR. "OdontID"- A computer program for dental identification. Personal communication. *Abstracts*, the 11th meeting of the International Association of Forensic Science. Vancouver, Canada, 1987. Special Edition. J Canad Soc Forensic Sci 1987;20(3):194.

201. Williams AB, Lorton L, Friedman RB. A new algorithm for use in computer identification. J Forensic Sci 1990;34(3):682-686.

202. Jones GF. NCIC "OFF-Line Searches". In Bowers LM, Bell GL eds. Manual of forensic odontology. Colorado Spring: American Academy of Forensic Science, 1995:60.

203. Fierro MF, Bishop DR. "New hope for identifying the unidentified". Am J Forensic Med Pathol 1984;5(4):349-371.

204. Tenhunen M. Computer Assisted Disaster Victim Identification Systems, 1990. *Abstracts*, the 12th meeting of International Association of Forensic Science. Adelaide. 1990.

205. The Computer Assisted Disaster Victim Identification System (CADVI). The ICPO - INTERPOL General Assembly. 1990.

206. Prinz JF. A forensic dental identification system with error tolerant algorithm and a review of the prevalence of error occurring in dental record. Med Sci Law 1993;33(1):4-10.

207. DeWinne J, Verdeyen F. Computer use in The Belgian DVI-Team. In: Jacob B, Bonte W, Eds. Advance in forensic sciences. Vol. Forensic odontology & anthropology. Berlin: Koster, 1995:243-246.

208. Solheim T. A Hierarchical Coding System for dental computerisation and reportion. *Abstracts*, the 14th meeting of the International Association of Forensic Science. Tokyo. 1996.

209. Arneman KM, Wilkins R, Griffiths C. Forensic dental identification: A simplified computerised system. Personal communication. 1990.

210. Ceddia J, Winship V, Clement JG. Design parameter for a Computer Aided Disater and Victims Identification system using dental records. *Abstracts*, the 14th meeting of International Association of Forensic Science. Tokyo. 1996.

211. Ceddia J, Winship V, Clement JG. A Computer Aided Disater and Victims Identification (DAVID) system. Personal communication. 1996.

212. Luntz LL, Luntz P. Handbook for dental identification. Techniques in forensic dentistry. Philadelphia: JB. Lippincott Co, 1973:137-141.

213. Vermylen Y. The use of telecopier in the long distance transmission of dental information in mass disasters. Med Sci Law 1980;20(2):89-92.

214. Churton MC. Disaster victim identification - The transmission of ante-mortem dental records by telephoto. Med Sci Law 1982;22 (2):79-90.

215. Southard TE, Baycar RS, Walter RG. Forensic Dentistry: Electronic transmission of computerised records. Mil Med 1985;150(9):492-495.

216. Southard TE, Pierce LJ. The application of digitized transmission to forensic dentistry. Mil Med 1986;151(8):413-415.

217. Brown KA, Taylor JA. Long distance transmission of dental radiographs. *Abstracts*, the 12th meeting of the International Association of Forensic Science. Adelaide. 1990.

218. Farman AG, Farag AA. Teleradiology for dentistry. In. Miles DA, Van Dis ML. eds. Advance in dental imaging. Dent Clin North Am. Philadelphia: WB Sounders, 1993;37(4):669-682.

219. The Computer Assisted Disaster Victim Identification System (CADVI). The ICPO - INTERPOL General Assembly. 1990.

220. Dentech For Windows' 95. Personal communication. 1996.

221. Oasis. Dental Surgery Management System. Personal communication. 1995.

222. Tomes CS. A Manual of Dental Anatomy Human and Comparative. The Homologies of the teeth – the milk dentition – the teeth of edentata, cetacea, and sirenia – the teeth of Ungulata. 5th edn. London: J. & A. Churchill, 1898:347-423.

223. Forensic Odontology unit, University of Adelaide. Personal communication. 1997.