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Contents

THE EFFECTS OF EXTREME TEMPERATURES ON COMPOSITE, COMPOMER AND IONOMER RESTORATIONS

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ABSTRACT

The composite resin, compomer and glass ionomer restorative materials used in modern dental practice are fire resistant and remain radiopaque. They shrink significantly and are likely to fall out of the cavities after being burnt, but they remain extremely important for identification purposes and it may be possible to identify the white filling materials used to restore teeth by their radiopacity and morphology. The radiographic density of these filling materials do not change significantly when exposed to heat and although they may be difficult to see with the naked eye, they will remain visible when radiographed. Furthermore, special care has to be taken when handling heated materials as their compressive strengths decrease significantly depending on temperature and time of exposure and damage is possible. **(J Forensic Odontostomatol 1999; 17: 1 — 4)**

Keywords: composite, compomer, glass ionomer, extreme temperature

INTRODUCTION

Forensic dentists are well aware of the resistance of human teeth to fire, a fact which has played a significant role in the identification of burnt bodies when ante-mortem dental records have been available.[1-10]

Combinations of dental restorations are as unique as fingerprints[11] and their radiographic morphology as well as the types of filling materials used are often the main features in identification. Gold, silver amalgam, porcelain and silicate fillings have varying resistances to high temperatures and are often unaffected even after prolonged exposure to fire[1] but acrylic restorations burn at 500°C, while they undergo minor shrinkage at lower temperatures.[12,14]

Present-day tooth coloured restorative materials consisting of composite resins, glass ionomers and compomers are being used in both the anterior teeth as well as the posterior teeth and are becoming far more prevalent in the mouths of patients, especially due to the trend of replacing amalgam with non-metallic fillings.

The purpose of this study was to examine the resistance of a number of these tooth restorative materials to high temperatures and to test some of their physical properties for forensic identification purposes.

MATERIALS AND METHODS

The dental restorative materials used in this test were as follows; Dyract compomer*, Fuji 2 LC glass ionomer**, TPH composite*** and Z100† composite. The materials were mixed according to the manufacturers' specifications and extruded from a syringe into uniform cylindrical forms (5 mm long with a diameter of 3.50 mm). Seven samples of each material were heated in an electric furnace (± 2°C) at the following temperatures:

1) 260°C for 5 minutes,
2) 370°C for 5 minutes,
3) 500°C for 5 minutes,
4) 370°C for 15 minutes,
5) 370°C for 30 minutes,
6) as control, the materials were tested at room temperature (25°C).

The materials were subjected to compressive strength tests on a Zwick Tensile Tester†† and the values noted in MPa (mega pascals). The dimensional changes of the materials were also measured with an electronic micrometer at the above mentioned temperatures and times, done by determining the volume of the cylinders from the measurements of filling material before and after the heating procedures.

The filling materials were radiographed before and after the heating procedures using a standard dental x-ray machine at 62 kV and Kodak Ektaspeed Plus dental film††† to test their optical radiodensities.

The colour changes of the materials were noted before and after the above heating procedures by using the Kodak Grey Colour Chart.

RESULTS

Box and whisker plots (Figs. 1-4) summarize the

* *Dentsply Ltd. Hamm Moor Lane, Addiestone, Weybridge, Surry KT152SE, UK.*

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*** *Dentsply International Inc. Milford, DE 19963-0359, USA.*

† *3M Dental Products St. Paul, MN 55144-1000, USA.*

†† *Zwick Gmbh & Co., Postf. 4350, D-7900 Ulm, Germany.*

††† *Eastman Kodak Company, Rochester, New York, 14650, USA.*

descriptive statistics of the compressive strengths of the 4 materials after heating at different temperatures for different time periods. Each plot shows an upper horizontal line representing the maximum compressive strength value at a specific temperature, a lower horizontal line representing the minimum compressive strength value, an intermediate box representing the range of 50% of the values and a line within the box representing the median compressive strength value (which is close to the mean value). The visual description of the data provides an overview of the range of all data and the distribution of the single values.

(A) Compressive strengths (Figs 1-4)

At room temperature (control)
The Kruskal-Wallis One-Way Annova on Ranks hypothesised a highly significant ($p<0.001$) difference amongst all 4 different materials. However, the regular Kruskal Wallis Multiple-Comparison test showed that the compressive strengths of Dyract and Fuji at 25°C were statistically significantly different and the strengths of Fuji and TPH as well as that of TPH and ZlOO differed statistically significantly.

At 260°C for 5 minutes
The Kruskal-Wallis One-Way Annova on Ranks hypothesised a significant ($p<0.07$) difference amongst all 4 different materials but the regular Kruskal-Wallis Multiple-Comparison test showed that the compressive strengths of only TPH and ZlOO differed significantly statistically.

At 370°C for 5 minutes
The Kruskal-Wallis One-Way Annova on Ranks hypothesised a significant ($p<0.05$) difference amongst all 4 different materials but the regular Kruskal-Wallis Multiple-Comparison test showed that the compressive strengths of Fuji and TPH, TPH and Dyract, and Dyract and ZlOO differed statistically significantly.

At 500°C for 5 minutes
The Kruskal-Wallis One-Way Annova on Ranks hypothesised a significant ($p<0.03$) difference amongst all 4 different materials but the regular Kruskal-Wallis Multiple-Comparison test showed that the compressive strengths of Dyract and TPH, TPH and Fuji, and TPH and ZlOO differed statistically significantly.

At 370°C for 30 minutes
The Kruskal-Wallis One-Way Annova on Ranks hypothesised a significant ($p<0.001$) difference amongst all 4 different materials but the regular Kruskal-Wallis Multiple-Comparison test showed that the compressive strengths of Dyract and TPH, TPH and Fuji, and Fuji and ZlOO differed statistically significantly.

370°C for 15 minutes
The Kruskal-Wallis One-Way Annova on Ranks hypothesised no significant ($p > 0.10$) difference amongst all 4

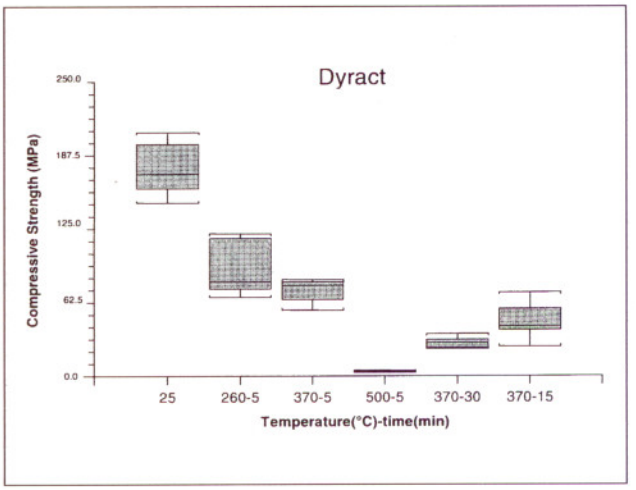

Figure 1. *The descriptive statistics (median, quartiles,maximum, minimum) of the compressive strengths of Dyract. at different temperatures and times.*

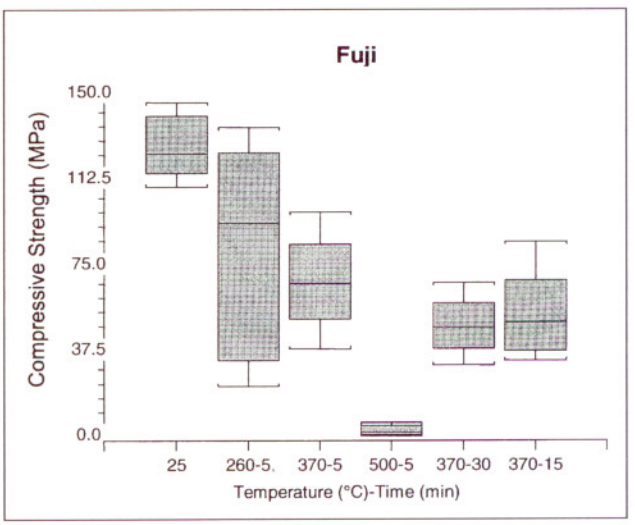

Figure 2. *The descriptive statistics (median, quartiles, maximum, minimum) of the compressive strengths of Fuji at different temperatures and times.*

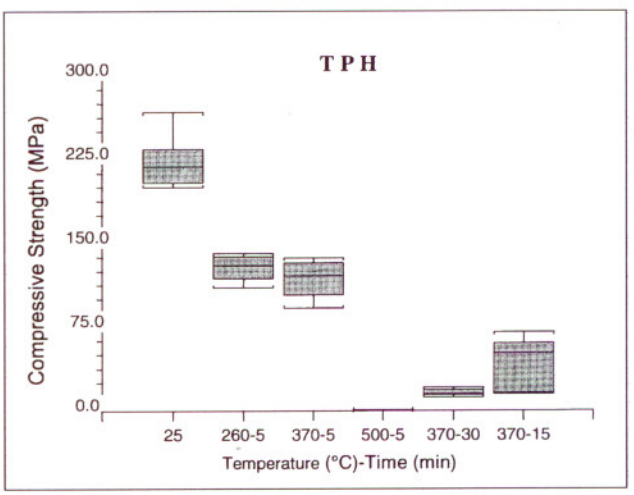

Figure 3. *The descriptive statistics (median, quartiles, maximum, minimum) of the compressive strengths of TPH at different temperatures and times.*

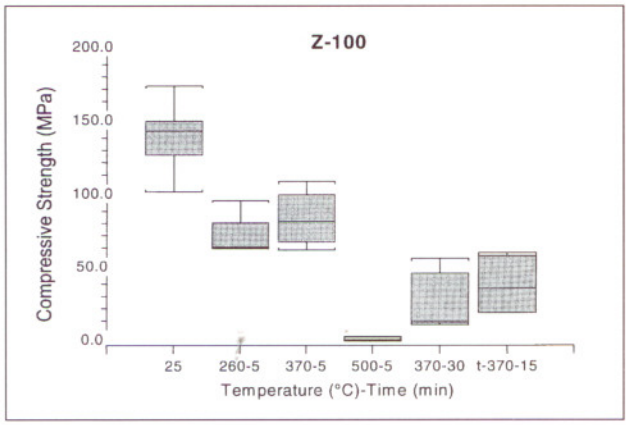

Figure 4. *The descriptive statistics (median, quartiles, maximum, minimum) of the compressive strengths of Z-100 at different temperatures and times.*

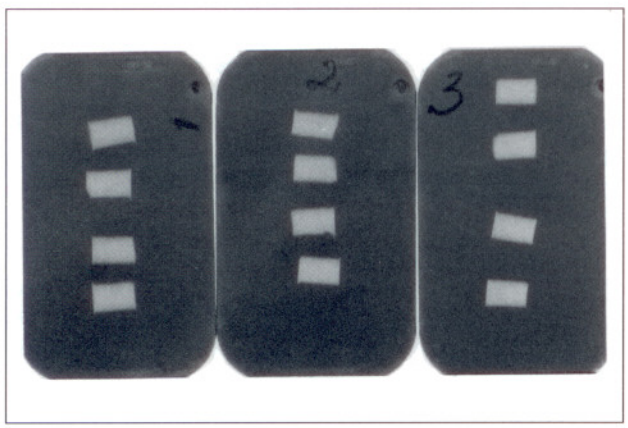

Figure 5. *Radiographs of the controls (no. 1), samples heated to 370°C for 5 minutes (no. 2) and heated to 500°C for 5 minutes (no 3). The materials from the top are: Dyract, Fuji, TPH, Z-100.*

different materials. The regular Kruskal-Wallis Multiple Comparison test also showed no significant differences.

(B) Shrinkage (dimensional changes)

When heated at 370°C for 5 minutes the volume shrinkage was found to be Dyract = 14.3% (sd = 5.3%), Z-100 = 5.9% (sd = 8.3%), Fuji = 18.6% (sd = 7.0%) and TPH 10.5% (sd = 5.7%) (Table 1).(Seven samples of each material were tested).

(C) Radiographs

The samples showed no significant change in optical radiodensity after being subjected to 370°C for 5 minutes or at 500°C for 5 minutes (Fig. 5).

(D) Colour

The colour of all the materials changed almost uniformly from the control (tooth colour) to a greyish-black after heating to any of the above-mentioned temperatures/ times, regardless of the original colour range of the filling material (Fig. 6). Only the glass ionomer (Fuji) gave a less blackish colour at 370°C (Figure 6).

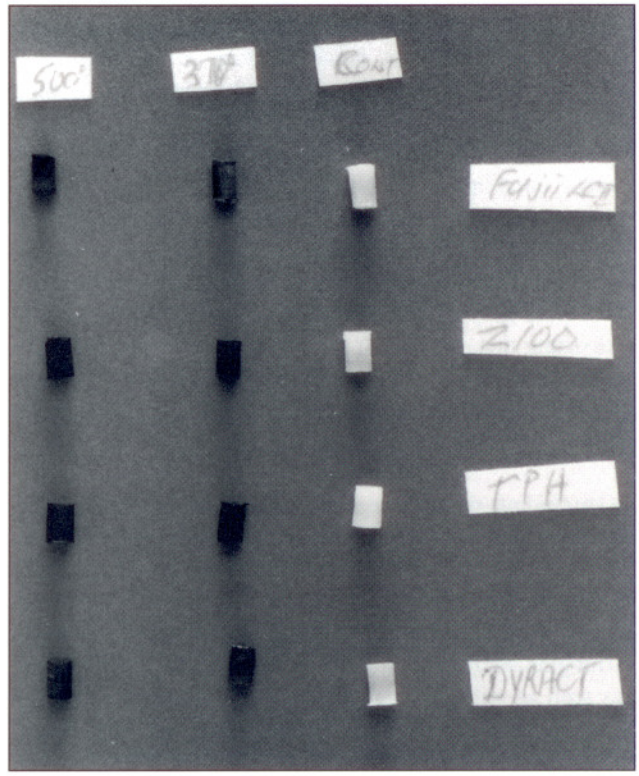

Figure 6. *A flash-photograph of the samples of the different materials heated at 25°C, 370°C (5 minutes) and 500°C for 5 minutes.*

DISCUSSION

At high temperatures enamel usually cracks away leaving bare dentine but teeth are usually protected by cheeks and the tongue which is bitten into as the victim burns, while the roots are protected by the jaw bones.

Teeth are remarkably resistant to heat if it is applied slowly, but if heated severely and suddenly they may disintegrate.[1] They can withstand temperatures of 1200°C which is the cremation temperature used in Britain.

In our study uniform samples of compomer, glass ionomer and composite resin were subjected to various temperatures for various time periods and these materials showed uniform resistance to temperatures ranging from 260°C to 500°C. The compressive strengths of all the materials decreased dramatically when exposed to high temperatures, they also showed different rates of shrinkage which varied from 5.9% to 18.6% (Table1) and which can be attributed mainly to the different chemical compositions of the materials as well as to different kinds of filler materials used during the manufacturing process.

Dental restorative materials have their own peculiar range of temperatures at which they melt or distort.[1] Gold alloy melts at 915°C to 1090°C. Silver amalgam has a range of temperatures which it may be resistant to depending on the amount of mercury it contains. Some amalgams may resist a temperature of 870°C whereas others may completely disintegrate.[12] Silicate restorations are able to withstand high temperatures and retain their form and

hardness[12] but they all turn white after being exposed to heat. Acrylic fillings however burn at approximately 500°C but undergo minor shrinkage at lower temperatures.[12]

Teeth containing composite resins, P-30 and Occlusin were tested by Botha[13] and exposed to a temperature of 900°C for 1.5 hours, results which showed complete destruction of the teeth, but the restorations only changed to a pale grey colour and were otherwise unaffected. In reporting this, the author did not refer to the compressive strength while in our study it was found that the values were reduced to approximately zero when heated at 500°C for 5 minutes (Figs. 1-4).

The finding of shrinkage in the materials ranging from 5.9% to 18.6% is significant and suggest that these fillings are very likely to fall out of the restoration cavities in teeth, especially from buccal and lingual surfaces. It can also be concluded for all 4 materials that the compressive strengths decrease markedly with increasing temperature as well as with increasing period of heat exposure (Figs. 1-4). Special care has to be taken when handling heated materials not to damage the shapes of these fillings as they can be radiographed and used for comparison purposes.

The radiographic density of these restorative materials does not change significantly when exposed to heat, but they all undergo a uniform colour change to a greyish-black. This suggests that they will be difficult to see with the naked eye, but will remain visible when radiographed.

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DENTAL PRINT MEDIA AND THEIR VALUE IN FORENSIC ODONTOLOGY

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ABSTRACT

Teeth are one of the most important factors in the identification of unknown cadavers. One of the most efficient methods the police have of publicizing a case is to publish the victim`s dental x-rays of treatment records in the dental print media which dentists will often recognize and thus be able to contribute to the identification.

To evaluate the efficiency of this procedure, 177 cases published between 1975 and 1995 were reviewed. The results show that only 3% of the cases were identified from recognition in the dental print media.

A survey of 500 dentists was carried out to gauge the efficacy of the presentation of identification cases in their dental print media. According to these results a revised method of presentation needs to be developed to improve the efficiency of this odontoforensic publicity medium. New technologies could also open new avenues for forensic identification such as digital x-raying or online data transfer. The Internet itself could be useful regarding international cooperation of forensic odontologists in the identification of unknown corpses. **(J Forensic Odontostomatol 1999; 17: 5 — 9)**

Keywords: Forensic odontology, dental identification, unknown cadavers, police announcements, dental print media.

INTRODUCTION

Teeth play an important role in the identification of unknown cadavers. In Germany, if normal procedures do not result in the identification of an unknown dead person within four weeks, police authorities publish the details of the case in the dental print media. This method of identification requires the cooperation of all practising dentists who with the use of their archives and recorded data of dental work, such as x-rays, can then contribute valuable information to the police to confirm the presumed identity of a person. This procedure is in most cases the last attempt by authorities to identify an unknown corpse and done at great expense. In this regard it is difficult to understand why written and graphic presentations of such cases are often less than successful and their importance misrepresented.

This paper describes a survey of German dental print media and dentists to quantify the success rate of identifications from police published notices and to elicit recommendations from the dentists for improvements in the attractiveness and readability of the notices.

METHODS

To evaluate the efficiency in identifying unknown cadavers, all cases which appeared between 1975 and 1995 in German dental print media were identified and examined. Of the 177 cases found most were published in the ZAHNÄRZTLICHE MITTEILUNGEN, which appears in Germany every fortnight with a total circulation of 70,000 copies.

To examine every case it was necessary firstly to contact the publishing authorities to enquire about further developments in the identification of the unknown cadavers. The authorities were then asked to complete a questionnaire detailing whether the corpse could be identified or not, and if so, was it as a result of the announcement in the dental print media and in what period of time. In all other identified cases the police were asked to describe the methods used which led to successful identification.

A second questionnaire was addressed to 500 German dentist recipients of the police announcements in order to determine how frequently published cases reached their notice and what they thought of the case presentations. The dentists were also requested to suggest improvements. The evaluation of the two questionnaires was to supply useful information for the future design of identification cases announced in dental print media and to improve their efficency.

Results of the police survey

The police authorities were very interested in our study and as a result were more than cooperative. It was thus possible to obtain information about 166 of the 177 cases published in the years 1975 - 1995, that is a response 94% of police authorities contacted who answered the questionnaire. Of 163 cases useful information was supplied, of which 60 cases resulted in identifications (37%). The files of three cases had been destroyed. Five of the 60 identified cases were successfully resolved following the responses of dentists who read the published

cases in the print media, an identification success rate in our study of 3%. The remaining 103 cases could not be identified.

In 48 of the 55 cases which were identified without dental print media, information about the methods used which led to identification was available. In most cases dental, i.e. forensic odontologic procedures, led to the identification and were as important as fingerprints in resolving 56% of examined cases (Fig. 1).

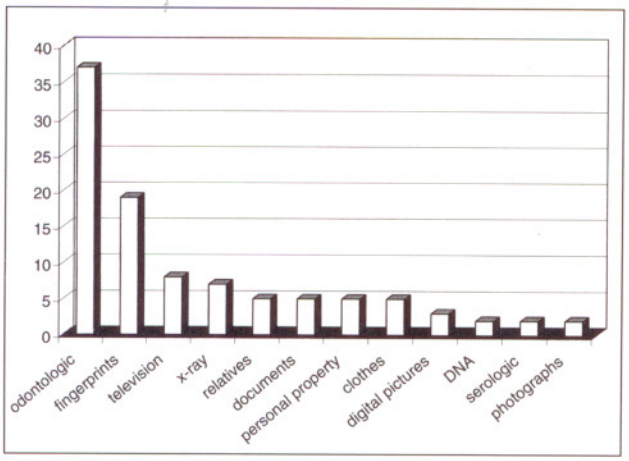


Fig.1 *Forensic identification methods.*

Results of the dentist survey

Of 500 questionnaires sent to German dentists, 180 (36%) questionnaires were returned. The dentists were highly interested in the identification work of the police, more than half read police announcements occasionally and up to a third read them almost every time they appeared.

Pictures and photographs in particular attracted the attention of dentists.The location where the cadaver was found and a description of existing dentures of the dead person were also important. The latter factor especially encouraged dentists to read the cases while the text of the announcements was considered to be the least interesting of all parameters (Fig. 2).

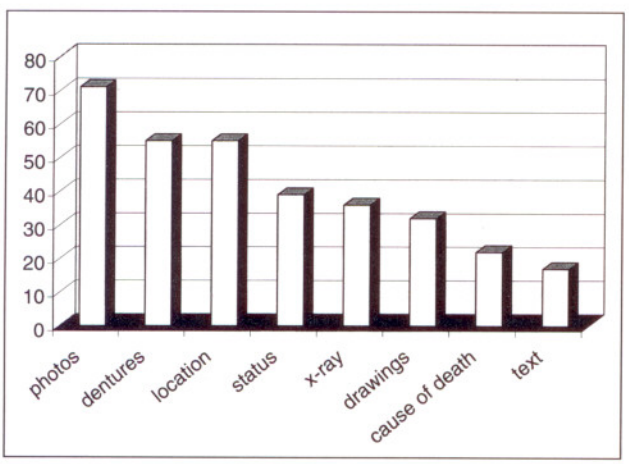
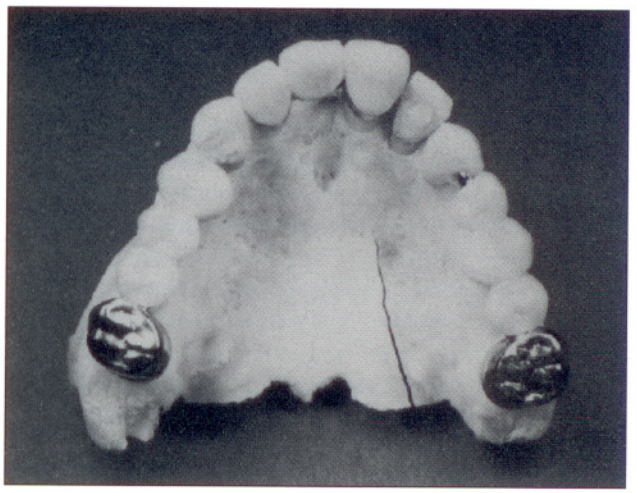


Fig.2 *Information in the announcements which attracted the attention of the dentists.*

Fig. 3 a, b *Occlusal view of maxillary and mandibular arches of a woman who died in a fire at the age of 32.*



3a. *Upper jaw. Prostheses: 3 dental bridges.*

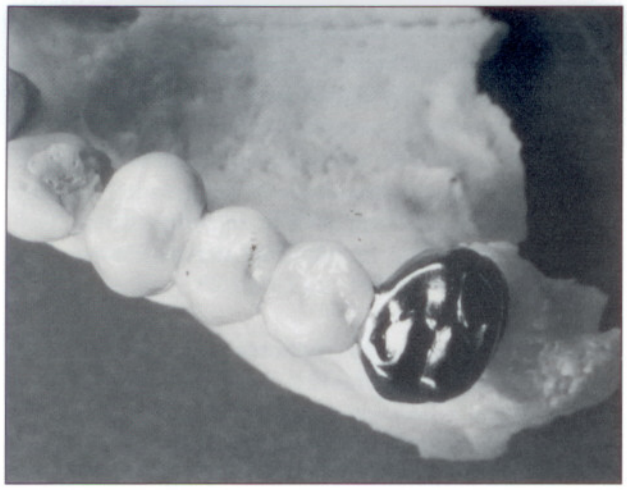
3b. *Lower jaw. Prostheses: 2 dental bridges.*

Ten out of the 180 dentists who returned the questionnaire had prior experience in cooperating with police in an identification case which stresses the importance of dental participation in these procedures. In these cases dentures and x-rays especially helped to identify the unknown cadavers.

The ease of recognition of dental parameters showed the importance of visual information for the dentists. Inherited anomalies and irregularities in tooth positon were regarded to be essential information and should therefore be reported when a case is published. The forms of the teeth and their number are apparently not decisive, although these parameters were useful at times.[1]

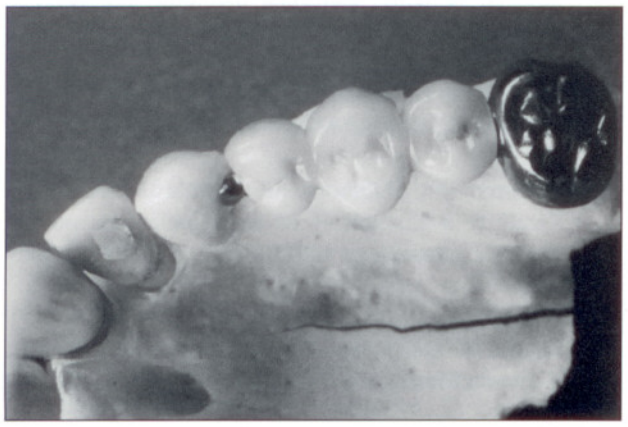
In general the published information and the presentations were sufficient for most dentists. Some indicated a wish for better quality pictures and photographs, some commented on the descriptions which were difficult to follow and badly arranged and most criticized the information as being presented in a rather boring manner. This perhaps explains why many dentists do not read the police announcements.

Fig 4 a, b, c *Findings in the upper jaw.*



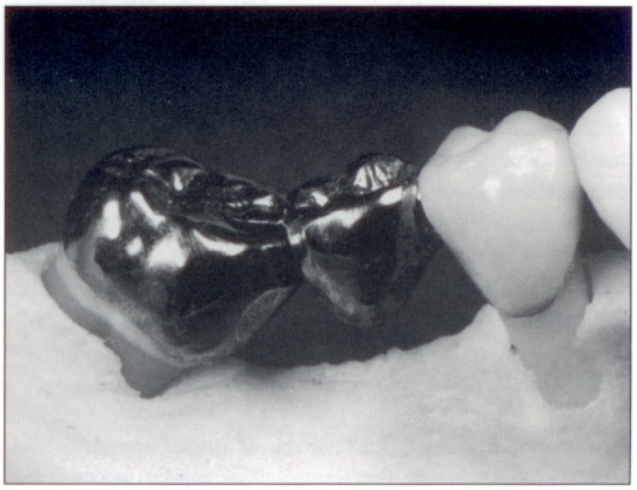
4a. *First gradiant. Four unit porcelain fused to metal (PFM) dental bridge replacing teeth 15 and 16; distal abutment tooth (17) without porcelain covering. Tooth 13 displays a temporarily filled disto-palatal cavity.*

4b. *Anterior teeth. Three unit PFM dental bridge replacing tooth 11.*



4c. *Second gradiant. Five unit dental bridge replacing teeth 24 and 26. The mesial abutment is tooth 23 on which the so-called retainer lies. With the exception of the distal abutment tooth 27 all pontics and retainers have metal-ceramic veneers. Provisional filling palatally in tooth 22. The probability of a rootcanal treatment was confirmed radiographically.*

Fig. 5 a, b. *Findings in the lower jaw.*



5a. *Fourth gradiant. Three unit PFM dental bridge with precision attachment replacing the missing tooth 46. The precision attachment was necessary because of the tilting of the abutment tooth 47. Pontic and distal abutment tooth are unveneered.*

5b. *Third gradiant. Three unit PFM dental bridge replacing the missing tooth 36. Mesial abutment and pontic are veneered, the distal abutment is not.*

Recommendations for future case publications in the dental print media

Photographs of facial views, dentures, teeth, especially views of the front teeth, plaster casts of the jaws and x-rays attract readers' attention. Visual information is best for recognition and therefore an essential part of an announcement. All pictorial material must be presented clearly and visibly if a police case publication is to have impact.

The charting of the dental status must be current and clearly legible to enable dentists to compare it with their own records. The charting must be done or at least checked by dentally trained staff who are able to detect mistakes before publishing.

Descriptions should be short, precise and easily readable

with an emphasis on important or peculiar facts pertaining to the case. The headline should name the location where the corpse was found or the crime occurred as this is of interest to most people.

An example of clear and unambiguous illustrative material is presented in Figs. 3 to 5 and are from a victim of fire for whom a facial reconstruction could not be made. The figures show clearly the form in which pictorial information can be published and they serve to complement the post-mortem dental chart, which is not presented here. Where the victim's identity is suspected, as in this case, a definite identification can be made from the completeness of the prosthodontic findings.

DISCUSSION

In order to improve the efficacy of police identification case publications in the dental print media, not only a better design and presentation in line with dentists'recommendations, but also the nature of the information given must be reviewed. Forensic odontology should be given greater importance in the education of dentists. This would place them in an even stronger position to notice and participate in police identification reports in the dental print media and the value of the participation of the dental profession, such as happened in the case of the Ramstein flight disaster,[2] would be further enhanced.

Correct and sufficient ante-mortem data and documentation by dentists are most important and a fundamental precondition for successful dental identification. Unfortunately the quality of dental documentation is not ideal in many cases and files often contain only failed treatments or there is only documentation of the current dentist's work without mention of existing and previous dental work.[3] Since it is not unusual for patients to change dentists these days it would be helpful to the police if dental work were documented in a kind of dental identity card, a development that has been demanded for years.[4,5]

During the post-mortem examination all dental findings must be monitored by dental staff to avoid mistakes in police case publications,[6,7] and standard procedures used to facilitate the documentation of the dental findings in the autopsy.[8]

Efforts have been underway for many years to mark dentures, which would be very helpful in identification,[9-11] but in Germany unfortunately there is no general tendency to do so. Many ways exist to mark dentures and a precondition is that the technique be cheap and easy to carry out; expensive or too complex a procedure will not succeed.[12] Medical information may also be stored on the recently introduced insurance card which contains a chip for personal patient data and which is now in use in Germany. There are, however, concerns about the protection of personal data if too much information is stored which is not controllable by the patient. Computers and suitably designed software are commonly used in the identification process.[13-15]

According to a study by the Forensic Institute in Mainz, Germany, the number of unknown cadavers to be identified is steadily increasing. The portion of all autopsies on unknown corpses made between 1985 and 1993 rose from 5% to 10%, an increase which is considered to be a consequence of the growing mobility and anonymity of society. The opening of the East European countries will probably add to this trend in coming years.

There are many new opportunities for forensic odontology offered by present and future technologies, such as digital x-rays which can be processed, mended,[17] filed or transferred via the Internet which could facilitate international cooperation in forensic identification. There are efforts in the United States and in Scandinavia[18] make greater use of the Internet for forensic odontology.

The number of cases identified from publication in dental print media was far too small to allow conclusions regarding which details of their presentations were important. It is however obvious that in almost all cases good photographs either of the face or of the teeth or denture of the unknown cadavers were part of the announcements in the dental print media. This factor was also found to be important in the dentist survey, which indicated that pictures or photographs attract the attention of readers and possess great impact in the recognition of an unknown person.

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A COMPARISON OF BITEMARK INJURIES BETWEEN FATAL WOLF AND DOMESTIC DOG ATTACKS

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ABSTRACT

Bitemark patterns in adult human victims following a fatal wolf pack attack and a domestic dog pack attack are compared. Both victims exhibited a concentration of wounds to the extremities, left and right torso, but not to the groin or internal organs. The neck and face of the domestic dog attack victim were primary sites of attack while the feral wolf pack victim was spared damage to the neck, but had facial tissue destroyed postmortem. Most punctures were found on the ventral aspect of the domestic victim and dorsal aspect of the feral victim. It is speculated that most wounds were attributable to dominant animals of both packs and in both victims and this suggests a co-ordination of activity between. Differences in bitemark patterns may well have been caused in part by differences in genetics, training, breeding, socialization and impetus of attack between wolves and dogs. Distinct differences in bitemark patterns were found in these two human victims of a wolf and domestic dog attacks. **(J Forensic Odontostomatol 1999; 17: 10 — 5)**

Key words: canid, bitemark analysis, behavior

INTRODUCTION

Between 1985 and 1993 there have been 15 reported deaths due to dog bites in Canada with an incidence of two deaths per 1000 bites.[1,2] There has never been a fatal wolf attack reported in Canada.

Victims of fatal attacks are most commonly the elderly and children under ten.[1,4-10] The head, neck and buttocks are reported to be the most frequent location of injury,[1,4,8-12] most incidents occur within family households and in adult humans of greater stature the relative inaccessibility of the head and neck to these animals reflects the ferociousness of an attack as they must leap to seize these areas.[12] Rib fracture and internal organ laceration may also occur.[13,14]

Purebred or mixed Staffordshire Bull Terriers, German Shepherds, St. Bernards, Huskies and Rottweilers are the dog breeds most frequently involved in attacks[1,4,6-11] and those most likely to bite humans are household pets, male, restrained, un-neutered and having exhibited previous aggression.[1,4,7-11]

Canids have a total of 42 teeth with the following dental formula: I3/3, C1/1, P4/4, M2/3.15,16 The cuspid teeth are the largest and allow them to puncture, slash, and cling to prey. The fourth maxillary premolar and lower first molar (the so-called carnassials) perform a tearing and shearing action while a crushing action is facilitated by the remaining molar teeth.[15]

Canid bitemarks on humans have been described as "puncture and tear marks" singly or in pairs.[12] Canid dental patterns and postmortem tissue wound-patterns have been used to confirm the involvement of dogs in human deaths.[5-8,9,10,13] In addition, characteristic postmortem bitemark injuries inflicted by domestic dogs have been described.[17]

The grey wolf (*Canis lupus*) is the largest living canid and is closely related to the domestic dog (*Canis familiaris*)[15-16] and more than fifty behaviour patterns have been observed to be common to both wolves and domestic dogs.[15]

The purpose of this paper is to describe systematically the patterns of perimortem injury in two human victims following a feral wolf pack attack and a domestic dog pack attack.

Case 1

A timber wolf pack was transported from a Michigan reserve to a northern Ontario wilderness compound in October 1993 for research and education purposes. This established fourteen year-old pack had no direct human contact prior to the attack save for brief sights of park personnel during feedings. In the early evening of April 19, 1996 a wildlife reserve worker entered the compound for unknown reasons and shortly thereafter was stalked, attacked and killed by five wolves. The worker had been wearing a forest ranger outfit consisting of dark cotton shorts and dark coloured shirt but no intact clothing was found on the body upon its recovery. Witnesses notified police during the attack who subsequently destroyed the wolves. After laboratory examination all animals were cleared of rabies and distemper. An autopsy was performed on the victim and cause of death was determined to be exsanguination. The remains of the wolves were removed to the Office of the Chief Coroner where necropsies were performed and the jaws removed for comparative examination. This is the first reported human fatality in North America attributed to feral canids.

Figure 1. *A typical canid dentition showing cuspid teeth capable of puncturing and tearing flesh.*

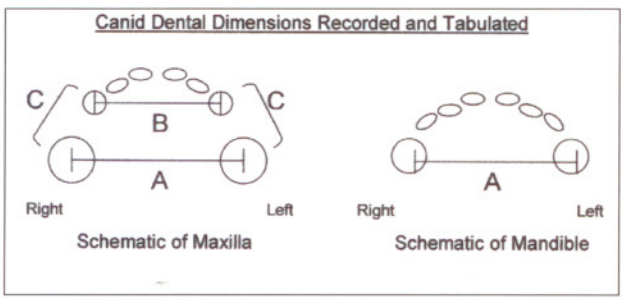


Figure 2. *Occlusal view of schematic maxilla and mandible depicting morphometric dental dimensions recorded. Dimension 'A' refers to intercanine distance in millimetres. Dimension 'B' refers to interincisal distance in maxilla. Dimension 'C' refers to distance between canine and ipsilateral corner incisor.*

Case 2

Two Staffordshire terriers kept as pets in a downtown Toronto rooming house had several months previously attacked and bitten the owner's room mate. The attack caused serious injuries, including a punctured lung, arm and leg. The victim had repeatedly abused the male and female dogs (named "Apollo" and "Rage" respectively) and one month later on July 1, 1995 while the owner was absent, the dogs again attacked the victim, reportedly dragging him down by the arm to the floor. A neighbour summoned help and returned with the police who refused to enter until the owner returned. Upon entry to the house

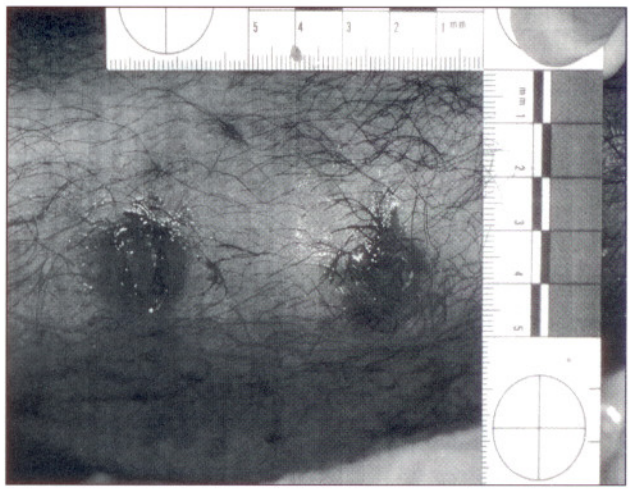


Figure 3. *Bitemark pattern injury evident on the skin due to a domestic dog bite. Injuries such as this one allowed metric and pattern comparisons to be made in order to determine which animal was responsible for a particular bitemark.*

the victim was found dead on the floor wearing dark blue denim jeans and a white cotton T-shirt. Clothing was torn but remained on the body and an autopsy determined the death to be due to exsanguination. Animal control officers destroyed the dogs and their bodies were taken to the mortuary where the jaws were removed for comparative examinations.

Bite injury analysis

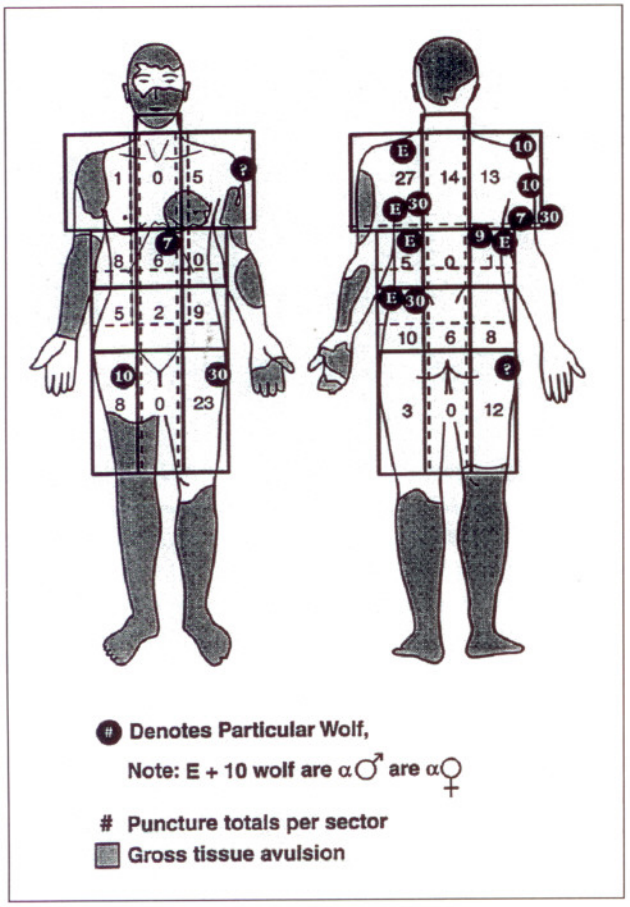
Photographs showing anteroposterior and lateral aspects of the dentitions of each of the five timber wolves and Staffordshire terriers were taken with and without an American Board of Forensic Odontology (A.B.F.O.) No.2 rule as reference. Irregularities in incisal teeth such as chips or missing incisors were recorded (Fig.1). The jaws were then carefully disarticulated and occlusal photographs taken with an A.B.F.O. No.2 rule oriented at the level of the incisal plane. Spatial relationships between anterior teeth were measured using a Boley gauge.

Each wolf was referred to as 7, 9, 10, 30, or E, derived from the autopsy drawers in which they were placed. The alpha male and alpha female ("alpha" denoting dominance in the social hierarchy of wolf packs) were labelled "E" and "10" respectively.

Photographs of bitemarks over the entire surface of the victims' bodies were taken at the time of autopsy (Fig.3).

RESULTS

Metric measurements of the dental dimensions of each canid jaw are displayed in Table 1. Measurements between puncture wounds found on each victim's body and speculation as to a particular animal perpetrator are displayed in Tables 2 and 3.



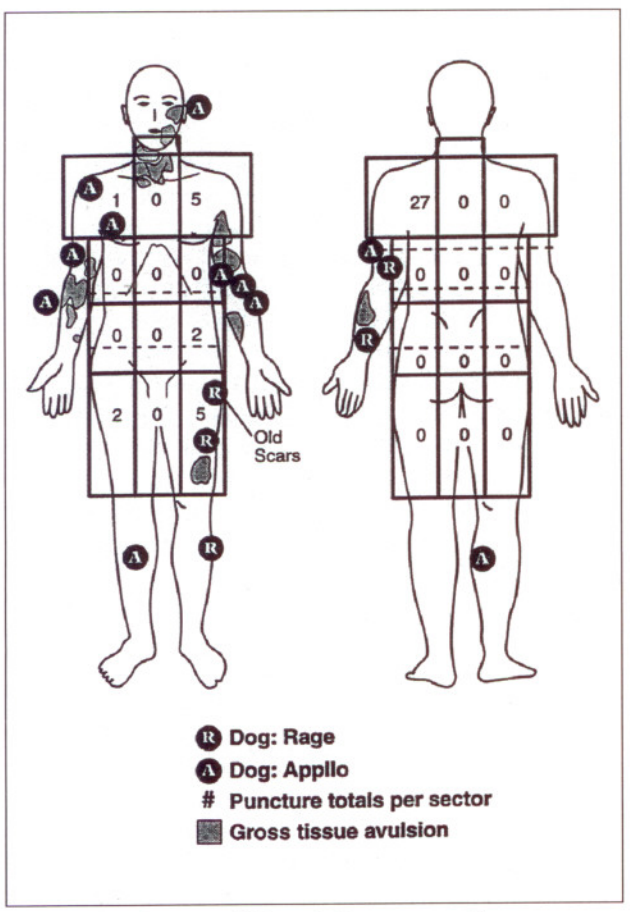


Figure 4. *Pattern of tissue injury present in (a top) feral canid attack victim and (b bottom) domestic canid injury.*

Puncture totals are tabulated in Table 4. Figures 4 a and b summarize descriptions of gross tissue avulsions, number of puncture marks per region as defined by grids and graphical display of concordance of puncture wounds with specific wolves/dogs based upon comparison of the bitemarks and the known dimension of specific canid teeth. A comparison of anatomic regions attacked between victims is outlined in Table 5.

DISCUSSION

A comparison of two isolated incidents is subject to innumerable variables which may influence the final disposition of bitemark injury such as the sheer number of animals involved in the attack, their particular demeanour, clothing worn by each victim and previous experience of victims with the offending animals. Nonetheless, the infrequent nature of a fatal wolf or dog pack attacks allows indulgence in a clinical comparison of injury patterns and our suggestions as to factors which may account for differences between the two over and above pure coincidence.

Feral Wolf Attack

All five wolves appeared to participate in the attack. The alpha male attacks appeared to be confined predominantly to the left dorsal of the victim while the alpha female attack appeared to be confined to the right deltoid area. Absence of drag marks in a caudo-cranial direction suggests lesions were produced after the victim had been brought down to a supine position. The subdominant male was considered to have attacked widely about the body but predominantly on the dorsal aspect of the victim. Cranial vault, hair and skin in the dog victim were intact and the victim's clothing was torn but not removed.

The rump of a prey animal is typically the focus of attack by wolves in the wild.[15] The next parts eaten are internal organs. The skull, mandible, spine, long bones and hide are left though chewing may be evident on the ends of long bones, pelvic ridges, scapula and mandible.[15]

In contrast to natural prey, the feral victim exhibited only a moderate amount of damage to the gluteal region (lower torso in Table 4). It is left to speculation whether this was due to the wolves' inability to access this region because of the victim's defensive flailing or due to the upright bipedal stance as opposed to the quadruped character of natural prey. The extremities were gnawed of most of their flesh similar to wild prey (Fig. 5) and the shoulders and shoulder blades exhibited most of the punctures as compared to the rest of the torso. This may simply be due to the accessibility of these regions to attack as the mid-section and pelvic ridges were left relatively unscathed.

Observations in the wild suggest the head and face are consumed only when the rest of the carcass has been eaten.[15] Postmortem injuries by household pets in search of food have been reported to consist of ingestion of easily

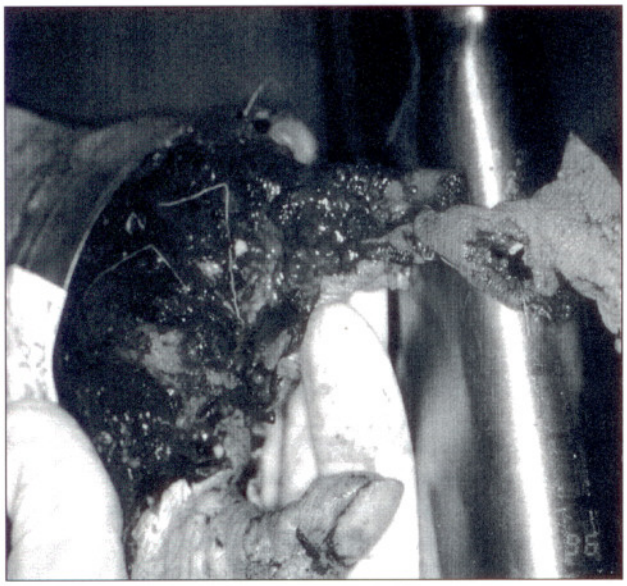


Figure 5. *Gross mutilation of four digits of the hand. Gnawing of the distal extent of hand is evident.*

accessible soft tissue like the nose and lips but sparing of eyebrows and orbital contents. Over 85% of the feral victim's head and face was damaged but orbital contents, eyebrows, ears, and neck were left intact. It is suspected that the damage reflects postmortem injury rather than damage following the primary attack.

After capturing wild prey, wolves generally leave only after all edible parts have been consumed. Domestic prey carcasses may be left after just the choicest parts are gone or abandoned following human intervention.[15] The feral victim exhibited focal damage to the extremities which may reflect the wolves' primary choice of edible parts.

Wolves seek their next kill immediately after leaving the most recent one.[15] This may account for the feral attack despite the fact that they had been fed only a day before.

Wolves' social structure is based on a linear dominance order separate for each gender.[15] The alpha male usually takes the initiative in prey attack and is most aggressive in all its aspects,[15-18,19] also performing a guarding function and initiates reactions to intrusions on the pack by humans, foreign wolves or other animals.[15,19]

Bitemarks consistent with the alpha male and alpha female were found more frequently than from other wolves on the feral victim's body and we suggest this indicates that alpha leaders were most aggressive during the attack. In the wild, subdominant wolves of the pack are reported to attack only when encouraged by alpha wolves.[16] Such a tendency to require facilitation by dominant members of a pack has also been observed in wolf cubs under controlled laboratory conditions.[16] It may be that the subdominant wolves engaged in attack of the lower extremities until downing their prey at which time the remainder of the attack was completed in a co-ordinated fashion led by their alpha leaders.

Domestic Dog Attack

Tearing and slashing of the face and neck of the domestic victim may indicate that the dogs did not intend to eat the victim but simply to kill. In each case only a few hours had elapsed after attacks before the victims' bodies were recovered, reducing the possibility of extensive damage from scavenger animals.

Based on the case history of the domestic attack it can be inferred that the victim was the focus of attack not as a food source but as a result of past incitement. The pattern of damage similarly reflects this as flesh on extremities was intact and fingers and toes had not been eaten.

The attacks were perpetrated by five wolves in one case and two dogs in another, which by virtue of numbers may theoretically account for differences in tissue damage. However, previous reports[15] of dog pack attacks in the literature involving four to seven dogs do not indicate significantly more puncture marks than the domestic attack described here, nor do they describe anything approaching the gross tissue avulsion pattern seen in the wolf attack.

The female dog Rage had previously been involved in attacking the victim's left leg which displayed typical scarring. Rage appeared again to be responsible for damage to the victims left leg in the final attack while the dominant male Apollo was implicated in most of the damage to the upper torso of the victim.

Fox[19] studied the effects of domestication on behaviour, prey catching and killing in canids by a controlled comparison between wild, domestic and hybrid canids. Prey catching and killing sequences were completed by wild animals but truncated in hybrids and even more truncated in domestic canids.

Motivation to kill may increase with increased experience with prey.[19] The domestic attack was not the first attack involving the victim and it is likely that the dogs' inhibition to severely maim or kill the victim had slowly been eroded with each encounter, since it has been demonstrated that domestic dogs that have apparently lost their killer instinct can be taught to do so again.[19]

The relative protective effect imparted by each victim's clothing is difficult to assess. Clothing was completely stripped off of the feral wolf attack victim, so it is complete speculation as to how much of a protective effect it had during the attack. Though clothing remained on the domestic dog bite victim, he still failed to sustain as much damage to exposed head, face and neck regions as did the feral victim. Longer pants were worn by this same victim but puncture wounds were still present on lower extremities. The effects of the colour of each victim's clothing on the respective attacks is unknown.

Table 1: *Morphometric dental dimensions of canids*

Animal	Particulars	Width 'A' (mm)		Width 'B'	Distance 'C' (mm)	
		Maxilla	Mandible	(mm)	Right	Left
Wolf 7	Female	48.7	48.9	34.2	13.5	13.5
Wolf 9	Male	48.7	39.5	30.0	16.5	13.3
Wolf 10	α-Female	45.9	41.2	45.9	14.1	13.2
Wolf 30	Male	49.9	42.2	33.0	15.11	6.2
Wolf E	α-Male	43.9	39.6	31.2	12.4	13.9
Rage	Female	43.1	37.3	36.0	9.6	8.7
Apollo	Male	47.2	38.5	34.5	13.5	14.0

Table 2: *Metric measurements of bitemarks on wolf bite victim*

DORSAL - Mx = *Maxillary dimension*, Md = *Mandibular dimension*

Location	Distance between punctures (mm)	Speculation re perpetrator
Right Arm	46, 46, 46	Wolf 10 (Mx=45.9
	48, 34, 34, 52, 52	?
Right Shoulder	47, 49	Wolf 7 (Mx-48.7)
		Wolf 7 (Md=48.9)
		Wolf 9 (Mx=48.7)
		Wolf 30 (Mx=49.9)
	45, 45	Wolf 10 (Mx=45.9)
		Wolf E (Mx=43.9)
Left Midsection	40, 40, 41, 42, 31	Wolf E (Md=39.60)
		Wolf 9 (Md=39.5)?
		Wolf 10 (Md=41.2)?
Left Shoulder	40, 44, 44, 44, 44, 44, 49	Wolf E (Mx=43.9)
Left Midsection	44, 44	Wolf E (Mx=43.9)
Right Midsection	50, 50	Wolf 30 (Mx=49.9)
Neck	26, 26, 33, 36, 36, 36, 38, 39	?

VENTRAL

Location	Distance between punctures (mm)	Speculation re perpetrator
Chest/upper abdomen	33, 48, 58, 58 Md=48.9)	Wolf 7 (Mx=48.7,
		Wolf 9 (Mx=48.7)
Left Deltoid	36, 53, 27	?
Right Leg	10, 21, 32, 33, 35, 40, 41	Wolf 10 (Md=41.2)
Left Leg	32, 33, 44, 49, 49, 49, 53, 50, 60, 60	Wolf 30

Table 3: *Metric measurements of bitemarks on domestic dog attack victim*

DORSAL - Mx = *Maxillary dimension*, Md = *Mandibular dimension*

Location	Distance between punctures (mm)	Speculation re perpetrator
Left Arm	31, 40, 40, 40, 40, 40, 44, 44, 44	Apollo (Md=38.5) Rage (Mx=43.1)
Left Forearm	44, 52, 52	Rage (Mx-43.1)
Right Calf	33	Apollo (Md=34.5)

VENTRAL

Location	Distance between punctures (mm)	Speculation re perpetrator
Left Face	47, 42, 42	Apollo (Mx=47.2)
Left Arm	29, 31, 32, 47, 49	Apollo (Mx=47.2)
Left Forearm	29, 39, 40, 47	Apollo (Mx=47.2)
Left Leg (old scars)	35, 37, 37	Rage (Md=37.3)
Left Leg	37	Rage (Md=37.3)
Right Shoulder	46	Apollo (Mx=47.2)
Right Forearm	46, 47	Apollo (Mx=47.2)
Right Shin	47	Apollo (Mx=47.2)

Table 4: *Number of puncture marks per victim and anatomic location comparing bitemarkings on feral and domestic dog victims*

	Feral Victim			Domestic Victim		
	Front	Back	Total	Front	Back	Total
Left Body	22	45	67	14	27	41
Centre Body	8	20	28	7	0	7
Right Body	32	34	66	14	0	14
Total	62	99	161	35	27	62
Upper Torso	6	54	60	26	27	53
Mid Torso	14	6	20	0	0	0
Lower Torso	11	24	35	2	0	2
Total	31	84	115	33	27	60

Table 5: *Comparison of anatomic regions attacked between victims*

Anatomy	Domestic	Feral
Face	Yes	Yes
Neck	Yes	No
Torso	No	Yes
Groin	No	No
Internal Organs	No	No
Arms	Yes	Yes
Legs	One	Both

CONCLUSIONS

Patterns of tissue damage differed considerably between victims of a domestic canid attack and of an attack by feral canids. Feral canids focused their attacks on the torso and extremities, stripping off soft tissue from the face and continuing to ingest the kill postmortem. The neck, groin, and internal organs were spared. Domestic canids on the other hand preferred to attack the extremities but did not strip flesh and ingest tissue from the head and neck regions. The ventral aspect of the domestic victim received the bulk of puncture wounds while the dorsal aspect of the feral victim received the most damage. In each victim, peripheral areas (left and right torso) received more wounds than the central areas but approximately equal numbers between sides. The mid-torso received less damage than the upper or lower torso in each victim.

A fundamental difference between feral and domestic canids with respect to attack inhibition under controlled conditions has been documented in previous studies.[19] The literature suggests that sequences of prey attack and feeding are innately universal but are simply suppressed in domesticated animals. The feral wolf pack stalked and killed their victim without previous encounter with the victim while the fatal dog attack appeared to be a culmination of previous episodes of incitement by the victim. Bitemark patterns suggest that wolves killed and immediately began feeding on their prey while the domestic animals were content with simply killing.

Based upon comparisons of morphometric measurements of each victim's wounds and jaw measurements of wolves and dogs, it may be speculated that dominant wolves attacked the upper torso primarily and subdominants the lower extremities. The greatest proportion of wounds were attributed to alpha dominant wolves. This may reflect a heightened aggressiveness and assertiveness as observed in the wild. Each domestic dog appeared to target the same regions as they had in previous attacks. It is however unknown whether this is simply coincidence or if in fact attacks were coordinated between canids in each case.

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AN APPROACH TO PERSON IDENTIFICATION BY MEANS OF DENTAL PROSTHESES IN A BURNT CORPSE*

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ABSTRACT

The identification of a burnt corpse is described. In this case it is suggested that the composition and properties of alloys used for dental prostheses are useful in determining the country of origin of the deceased in addition to the role they could play in an ordinary dental identification process. **(J Forensic Odontostomatol 1999; 17: 16 — 9)**

Key words: Burnt corpse, identification , composition and properties of alloys, dental prostheses.

INTRODUCTION

Experience in the field of forensic pathology shows how difficult and demanding it is to tackle and resolve problems such as scene-of-crime investigation, victim identification, establishing the cause, manner and time of death, as well as toxicological and haematological tests arising from the discovery of a burnt corpse.

Those investigations are made particularly difficult by the destruction caused by fire on the body and its clothing. Typical problems include alteration of the skin, loss of distinguishing marks (e.g. tattoos) and finger prints, morphological alteration of the teeth, destruction of personal effects (jewellery, orthopaedic prostheses, dentures, metal buttons, etc.), which often prove crucial in identification when death is caused by factors other than fire.

This study of the forensic value of the dentition was prompted by a case in which these problems were highlighted. We describe the approach to person identification by the examination of the dentition which is relatively fireproof and which plays a crucial role in identifying burnt corpses. The materials used to manufacture the restorations involved will also be discussed.

The medicolegal investigation of a fire victim[1] requires collection of material from the burnt body (including fragments of clothing and jewellery), identification of the body (by scars and tattoos, results of previous surgery, defects known to be present before death, finger printing), determination of the state of the victim before death by testing for drugs including alcohol as well as carbon monoxide, evidence of antemortem wounds in order to establish homicidal, suicidal or accidental injuries and evidence of natural disease and of the rapidity of death. Moreover in the presence of a burnt corpse it is important to seek evidence of torture such as cigarette burns on base of toe or genitalia and inflammatory elements such as lighter fluids, gasoline and torch burns.

Finger printing, when possible, can be carried out by means of the technique used on decomposed cadavers (burnt or putrefied).[2,3]

The study of alloys used in dental restorations is helpful in determining the country of origin and the social standing of the victims. They may be divided into noble and non-precious alloys for fixed or removable prostheses and information about a number of alloys commonly used in Italy and other developed countries was readily available upon enquiry. Manufacturers were however unable to inform us about alloys used in developing countries such as Eastern Europe, Latin America, Asia (except Japan) and Africa, and of course the absence of these alloys on the Italian market made investigation more difficult.

In this report we describe a person identification in which we tested the composition and properties of a range of alloys.

Case report

The corpse of a female to be identified was subjected to the procedure based on Carella[2] and Dorrego[3] for the isolation of finger prints. In addition dental examination revealed the number of teeth, alterations in tooth shape and size, all restorations as well as details of prostheses, and comparative analysis was possible by using x-ray and photographic material. The most significant data obtained from the examination indicated a subject with little concern for oral hygiene, possibly suffering from metabolic illnesses or addiction. The extensive use of bridges was also the result of premature loss of teeth. The composition of the alloys used could be analysed and delivered a clue as to the country of origin, which would probably coincide with that of the deceased.

* *A preliminary communication was presented at the First National Meeting of the Italian Group of Forensic Anthropology and Odontology, May 12-14, 1994, Desenzano sul Garda (BS), Italy.*

The alloys from the bridges in the identification subject were tested with SEM (Cambridge 120)* equipped with the Oxford EDX ISIS microanalysis system,** and found to be a copper-resin alloy containing mostly copper, and small amounts of iron, zinc, potassium and calcium (Fig. 1), and used only very occasionally in Italy and other developed countries but more frequently in the countries of eastern Europe.

The case was resolved by means of finger printing, dental examination and bridge alloy analysis and confirmed that the victim was a 28 year-old Romanian woman whose finger prints happened to be on record. It was also possible to obtain dental records from a dentist and the dental technician responsible for making the copper-resin bridge.

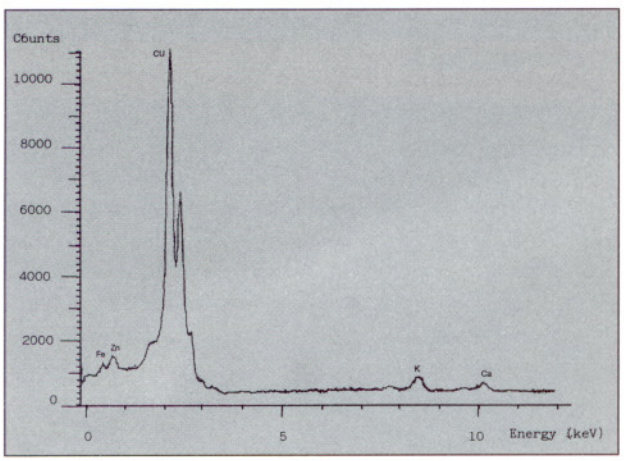

Fig.1 *Spectrum of alloy used to manufacture the bridgework in the identification case.*

DISCUSSION

Dental identification procedures can be divided into three phases:[4] postmortem processing of remains, antemortem record reconstruction and antemortem-postmortem comparison. The first phase consisted of dental and radiographical examination of the teeth, in order to establish a clear postmortem dental record. In the second phase an antemortem dental record was compiled from the dental records and radiographs obtained from the treating dentist, including treatment at the last visit. The third phase consisted of comparing antemortem with postmortem records.

The idea of studying alloys used to manufacture both fixed and removable prostheses, in order to help identify burnt or skeletonized bodies arose when a case of homicide-associated burning was referred for identification. Dental prostheses are as unique as the dentition and are important because their materials are resistant to destruction and where person identification by means of the traditional methods (finger printing, tattoos, scars, etc.) is not possible. The study of the alloys used in the prostheses can be useful in establishing the country of origin, the occupation and the social standing of victims.

In Italy and western countries the metals used are mostly alloys of noble metals, notably gold and platinum-palladium. In eastern European and in developing countries prostheses are made of non-precious alloys such as stainless steel, copper-resin, cobalt-chromium-nickel-iron and nickel-chromium-beryllium.

Many factors can hamper the identification of the alloys used in dental prostheses and their composition including a crucible contaminated by environmental dust or by previous fusion products, mixture of alloys and the presence of trace elements not recorded by the manufacturers. This was emphasized by investigation of a range of alloys by SEM and the finding of contamination (Table 1).

Table 1. *Differences in the composition of alloys as quoted by manufacturers and after analysis by SEM.*

Quoted by manufacturers	Analysed by SEM	
1. Au, Pd	Au, Pd, Ga, Cu	(Fig. 2)
2. Au, Pd, Cu, Ga	Au, Pd, Cu, Ga, In	(Fig. 3)
3. Au, Ag, Pt, Pd	Au, Ag, Pt, Pd, Ga, Cu	(Fig. 4)
4. Au, Pd, Ga*, In*, Ru*	Au, Pd, Ga*, In*, Cu	(Fig. 5)
5. Au, Pt*, Pd	Au, Pd, In, Ga, Cu	(Fig. 6)

* *traces*

The fact that manufacturers are reluctant to provide complete information about their products makes the identification of alloys used in prostheses difficult. They are naturally afraid of the risk of industrial espionage and they do not record the minor elements added to the alloys, useful in distinguishing them from one another, and they sometimes communicate incomplete technical data.

In summary therefore, there is a lack of an official list of the identity and composition of materials, including the alloys; the inaccurate or incomplete dissemination of information; the possibility of confusing the chemical and physical features of different alloys; the marketing and use of recast and mixed alloys (unethical); and no information about chemical composition and identity of materials used in prostheses from developing countries. In fact, our SEM testing was unable to relate the prosthesis made of copper-resin to any other alloy, particularly as copper-resin alloys are no longer available in Italy. For this reason it is suggested that alloys used to manufacture prostheses in developing countries should be studied and made available for use in person identifications.

Legislative measures which force manufacturers to make public all the components and other technical data in their alloys are necessary and would be helpful to investigators working in forensic odontology.

* *Cambridge Instruments Ltd., Cambridge, UK.*

** *Oxford Instruments Scientific Research Division, Old Station Way, Witney, Oxford, UK.*

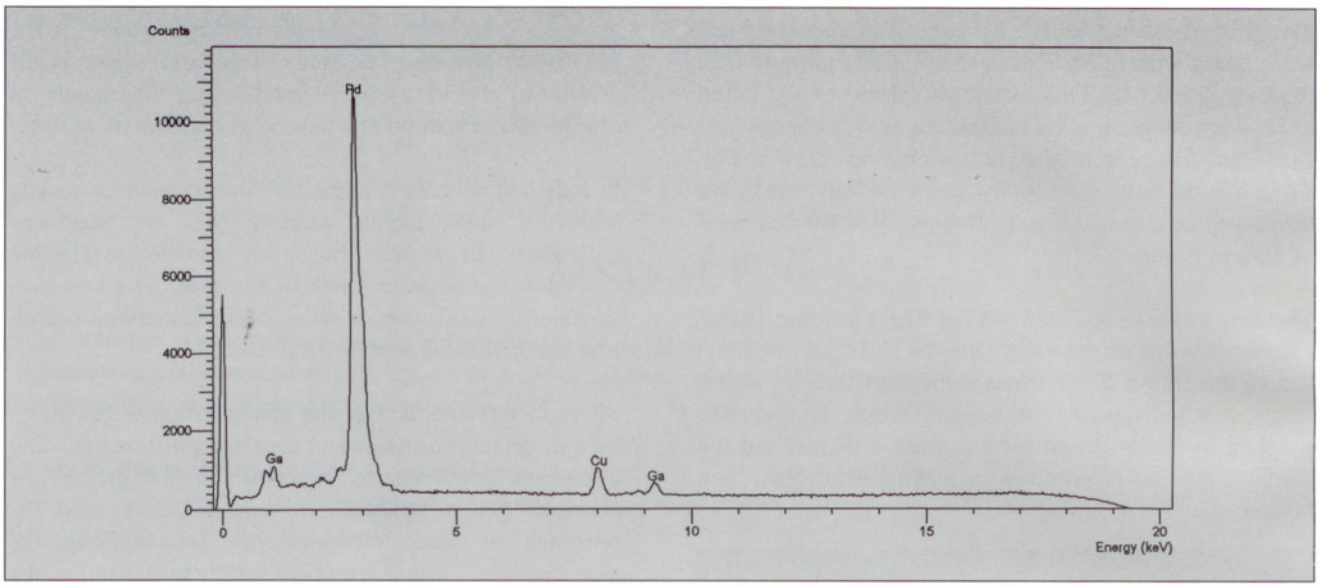

Fig.2 *Spectrum of alloy No. 1 (Table 1)*

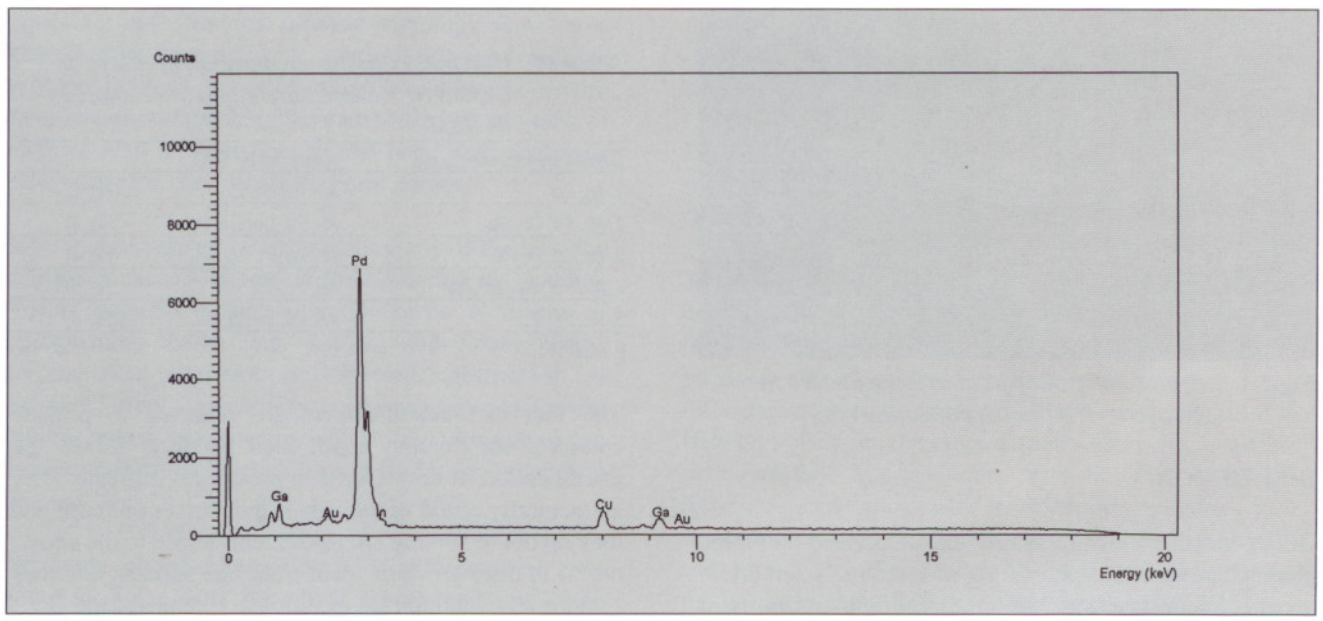

Fig.3 *Spectrum of alloy No. 2 (Table 1)*

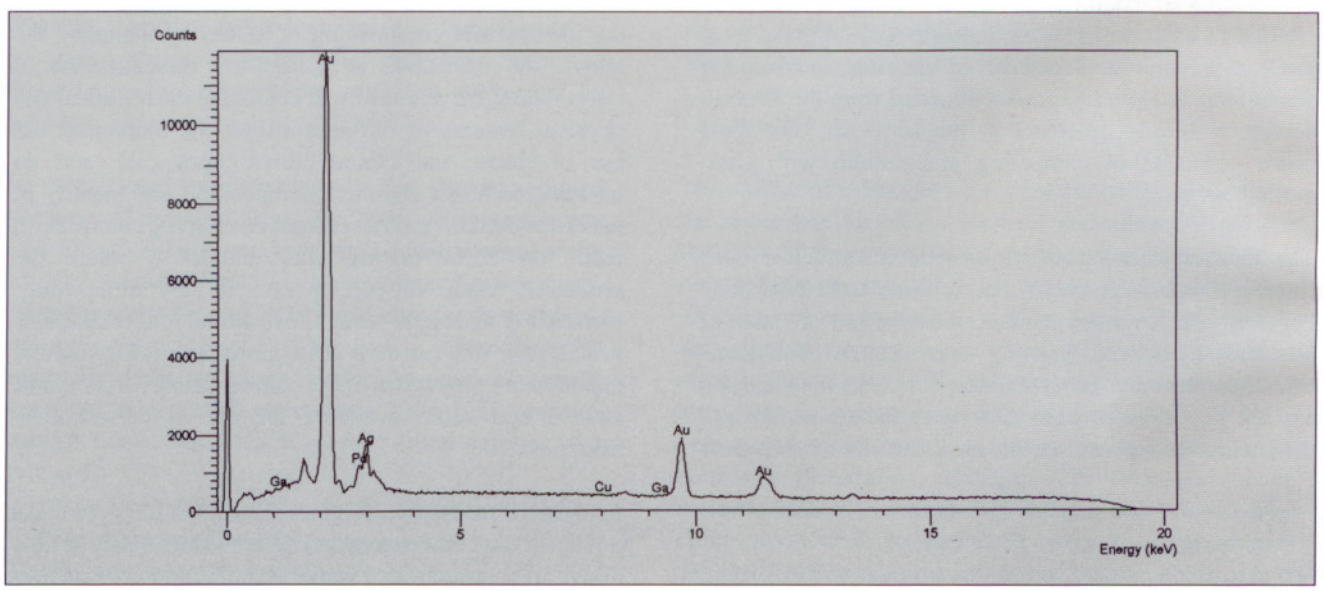

Fig.4 *Spectrum of alloy No. 3 (Table 1)*

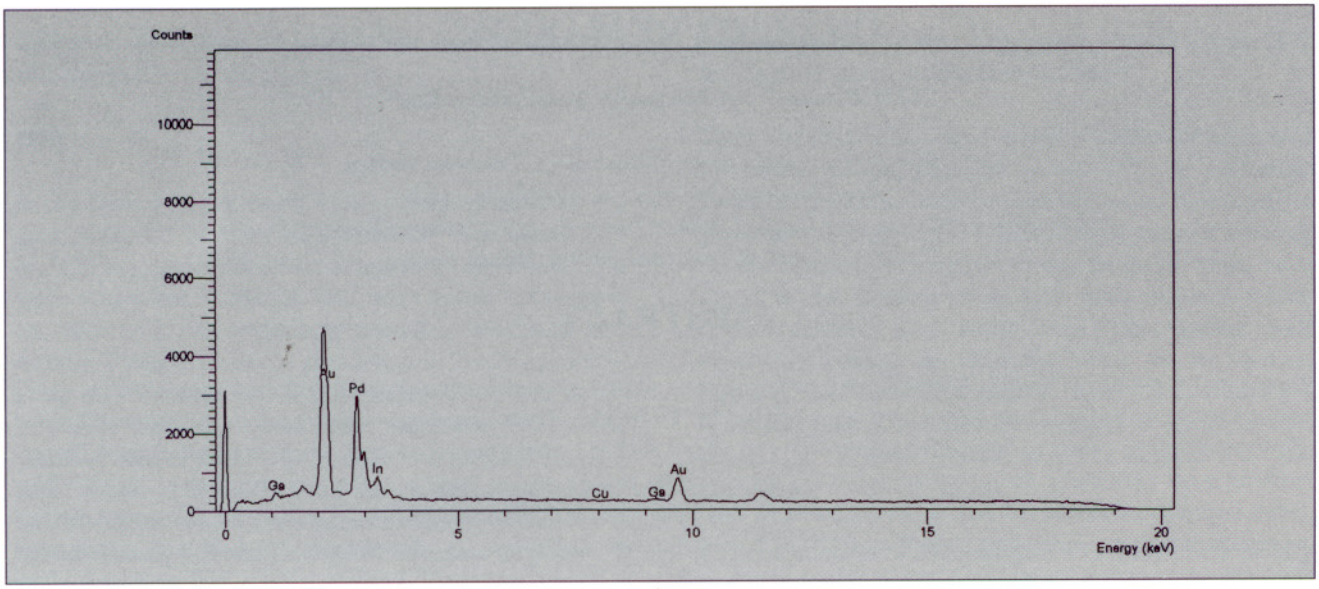

Fig.5 *Spectrum of alloy No. 4 (Table 1)*

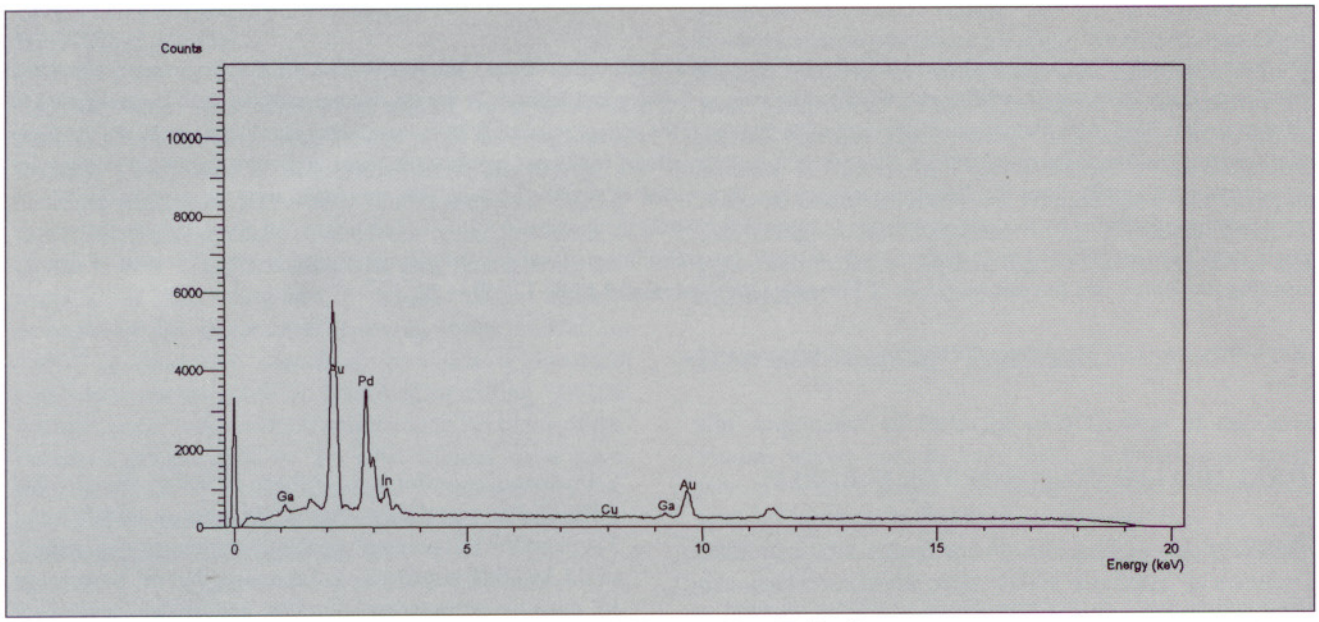

Fig.6 *Spectrum of alloy No. 5 (Table 1)*

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ON DENTURE MARKING

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ABSTRACT

During the last decades in Sweden dentures have been permanently marked with a stainless steel metal band incorporated into the acrylic and containing the patient's birth date, a special number, and "S" for Sweden. The last recommendation issued by the National Board of Health and Welfare states that "the patients shall always be offered denture marking and be informed about the benefit thereof. Denture marking is not permitted if the patient refuses it". Requirements for denture markers have been that they should be biologically inert (when incorporated into the denture), not be expensive, be easy to inscribe, be possible to retrieve after an accident, and survive elevated temperatures for a reasonable time under normal circumstances. Although the frequency of edentulousness has decreased in recent years due to the improvement in oral health there remains a need to address the issue of marking of complete dentures, because there is a large variation in the oral status of populations in different countries. Given that only one marked denture can reveal the identity of a deceased person when all other methods fail to do so, makes it worthwhile. Furthermore, denture marking is important in long-term care facilities.

We have investigated the issue of denture marking in Europe and in the United States. The results from the European survey show that denture marking is, to our knowledge regulated by law only in Sweden and Iceland. In the US denture marking is so far mandatory in 21 states while New York State requires dentures to be marked if the patient requests it and several other states impose the obligation to mark dentures on long-term care facilities. Since there is no international consensus regarding the issue of denture marking it is important to address it. A survey from the Nordic countries[1] has shown that if denture marking was in general use, the contribution to the establishment of identity by forensic odontology in cases of fire would increase by about 10%. This means that about 25 more individuals could have been identified if their dentures were marked. Increased international collaboration is needed to solve the issue of denture marking for clinical and forensic purposes. **(J Forensic Odontostomatol 1999; 17: 20 — 6)**

Keywords: Forensic odontology, Identification, Denture marking

ORAL HEALTH STATUS OF THE ELDERLY

Europe

National surveys on the prevalence of edentulousness in selected age groups during 1970-1990 in the Scandinavian countries[2] indicate that it will be an oral health status issue well into the future. In Sweden during the period 1975-1995 the number of individuals with dentures in the age group 65 to 74 years has decreased from 52% to less than 39% and Helldén *et al.*[3] found that 54% of persons older than 79 years had complete dentures. However, in a recent study among 88 year-old persons[4] 54% of the elderly living in their own homes were edentulous whereas edentulousness was more common (71%) among hospitalised patients. They also found a relationship between the prevalence of edentulousness and place of residence with a tendency towards a lower percentage in urban areas compared to villages. This fact should be kept in mind when different figures regarding edentulousness and denture wearers are to be compared. These figures should be compared with data from Finland showing that about 80% of the individuals in the age group 65 to 74 years have dentures in both jaws whereas in Denmark 59% in the age group 65-81 years were edentulous.

Corresponding information from Norway reveals that 47% of the population above 65 years is edentulous.[5] Nordenram[6] has pointed out that the proportion of elderly in the Swedish population is increasing but the percentage of edentulous persons (females and males combined) decreased from 30% to 24% between 1988 and 1990 among long-term hospital residents in Stockholm. However, recent work on dental caries and related factors in old age[7] found that 54% of 88 year-olds in Göteborg had no teeth. It is important to compare the frequency of edentulousness in different areas. In Uppsala, Sweden, the frequencies of edentulousness for the age groups 50-59 years, 60-69 years and 70+ years were 0.6%, 2.2% and 5.9% respectively,[8] the numbers of examined individuals for the three age groups being 2940, 1926 and 2460 respectively and these figures could be compared with the results described by Nordström.[9] He examined the change in edentulousness between the years 1981 and 1990 among 70 year-old individuals.

The frequency of edentulousness among women in 1981 was 31.3% and 21.4% in 1990. In men the frequency of edentulousness was higher in both 1981 and 1990 (53.3% and 35.7%) and the results from the last two reports [8,9] have shown that edentulousness is more common in the northern part of Sweden (Umeå) In contrast, in the United

Kingdom, about 88% of people older than 65 years are edentulous.[10]

USA

In the United States, about 42% of persons between the ages of 65 and 74 years are edentulous[11] and about 37% of 1156 non-institutionalised elders over 70 years-of-age were edentulous.[12] Similar data were found for women and men and were negatively related to education and income. Projections of the population of elders aged 65+ years and 85+ years are both expected to increase in the year 2050 and some authors have suggested that by that year less than 15% of the population will be edentulous.[13] Even if such predictions are accurate, it has been proposed that the dental profession must be prepared to care for 9 million elderly persons in need of complete dentures 25 years from now.[12]

EDENTULISM, DENTURES AND IDENTIFICATION

Gypsum casts will always be useful as a tool in identification, but they cannot be a proof of a person's identity. Casts were actually used when identifying a deceased edentulous fire victim[14] and in a murder case in Luton, England, gypsum casts of the upper jaw from a dentist's files could be compared and matched to the maxilla of the deceased.[15] These cases clearly demonstrate the importance of saving study models. In 1966[14] a case was described in which a drowned edentulous person could be identified by fitting "an old denture" in the mouth which was found in the home of the deceased and provided by the wife. Similar cases have been reported[16,17] where dentures were found in the homes of the deceased and either fitted well or where the ruga patterns could be matched.

In a car fire a victim was identified by the type of teeth used for making the denture *i.e.* Biodent 13-35A and the number corresponded exactly with the notes in the dental record of the missing person.[18] The importance of considering information about the manufacturer of the teeth, type, size, shape and colour could be very valuable, but as has been pointed out,[19] there are no recommendations or laws regarding these matters from the Swedish National Board of Health and Welfare. It is a sobering thought[14] that most problems with the identification of deceased persons were encountered in complete denture cases.

THE VALUE OF IDENTIFICATION MARKING OF DENTURES

In clinical dentistry: geriatric institutions/medical and chronic disease hospitals

The idea of marking dentures was first mentioned in the early twenties[20] and it has been said that a denture can be equivalent to natural teeth in identification,[21] but not since they are removable and cannot prove identity like teeth or fingerprints which are fixed to the body.

The value of ID-marking of dentures has been emphasised by many throughout the years.[20-34] A particular comment[10] was that it is common in nursing homes and in geriatric and psychiatric wards to find patients wearing dentures not belonging to them. Dentures have been found in the laundry, there have been cases in which several dentures have been cleaned all together with obvious problems in returning them to the correct owners[34] and also with patients who remove dentures when they take pills. Some elderly subjects misplace their dentures in the often difficult period of adaptation to new prostheses.[19]

To mark dentures is a way to make everyday life in elderly people's homes and in mental hospitals less difficult[20] although despite the passage of several years little progress has been made in the acceptance and implementation of denture marking. We therefore strongly believe that one way of dealing with the matter is for a wide spectrum of authorities such as represented in the authors of this paper, which is a collaborative effort between a University, Federal Bureau of Investigation, National Board of Health and Welfare and a University of Technology to make an effort to bring clinical, forensic, legal, and technical aspects together to be discussed and highlighted.

In forensic odontology: significance

The importance of teeth for identification of deceased victims whose remains have been mutilated or severely altered by, for example fire, water or traffic accidents is a well known fact. If dentures are included they are often retained in the mouth and remain intact or only slightly damaged even in the most violent accidents. In a study[12] it was found that about 30% of the patients that were examined (n=1156) wore their dentures in bed at night and the value of ID-marking of the dentures is therefore further emphasised.

Forensic cases involving denture wearers

The earliest recorded single case of identification of a body from a gold denture was the Countess of Salisbury who was burned to death in 1835.[35] In the United States a murder case involving fragments of a gold-based denture has been described[36] and the mass murderer Haigh thought that he had disposed of a female body only to find that her dentures remained intact and were later identified by her dentist.[37] One victim from the Kings Cross fire in London wearing full dentures still remains unidentified because they are unmarked, which clearly demonstrates the existing need. A survey from the Nordic countries[1] showed that if denture marking was in general use, the contribution to identification by forensic odontology in fire cases would increase by about 10% which would mean about 25 more individuals identified.

THE USE OF ID-MARKING

Frequency of ID-marking

In a study of forensic odontology cases in Sweden during the period 1980-1989 it was found that among 167 cases with complete or partial dentures only 32 (19%) were marked with the personal number.[38] There has however been an improvement, since recent information[39] reveals that the number of dentures now marked is 50%. This is in accordance with the data presented by Bengtsson *et al.*[40] who found that 50% of the dentures among 464 patients in elderly people's homes in Göteborg, Sweden were marked. However, in a more extensive study[41] involving twelve aged care homes it was noted that about 40% of the dentures were marked.

In the United Kingdom denture marking is not a mandatory requirement and only 7 dentures out of 97 from ten mass disasters had an identification mark.[42] It was also pointed out that the failure to mark dentures constitutes a major problem for forensic odontologists, a view which is also supported by another report[43] where it was found that the percentage of identified victims from a survey would have increased from 58% to 82% if dentures had been marked. The need for denture marking was brought to the public's attention[10] following the fatalities at the Bradford, England, football stadium fire where only two percent of the denture wearers could be identified by denture marks. In a recent article on dental identification of war victims from Pretrinja in Croatia[44] it was stated that the findings support the suggestion that dentures should be marked with names or security numbers.

Attitudes to ID-marking

Attitudes to identification of dentures have been investigated[10,45] and the results show that patients do not object to denture marking, while in the latter paper it is stated that the dental profession itself seems to be responsible for the non-marking of the dentures. A sample from the southern part of Sweden[45] could of course not be representative, but the result points to the fact that the recommendations of the Swedish National Board of Health and Welfare are not being complied with.

The use of ID-marking in different countries

Dental societies and/or the societies for forensic odontology in the different countries of Europe have been contacted by mail and the following report sets out the policies for the countries from which we received written answers. There is no legislation or regulation to mark dentures from either dental association or other official board in: Croatia (nor in four other countries of former Yugoslavia), Belgium, Denmark, Finland, France, Germany, Greece, Holland, Ireland, Norway, Latvia or Lithuania. Denture marking is however carried out upon the initiative of some of the dentists in Norway, Holland and in Germany. In Denmark, dentures are being marked for patients in institutions if the community so wishes while in the Netherlands, denture marking is practisedbut the frequency is low. In contrast, all dentures that are made in the Dental School, University of Iceland are marked.

DIFFERENT MARKING SYSTEMS - A REVIEW OF THE LITERATURE

Different methods for short- and long-term denture marking have been suggested. They can be divided into two categories: surface or inclusion techniques.

The surface technique has the advantage that it is cheap and easy to apply. If the purpose with the marking is only to avoid mix-up and loss of dentures during hospital, nursing home or aged care institution daily routines, some of the surface techniques are adequate.

If the forensic aspects are considered the identification mark must be more comprehensive and the criteria for the ideal denture identification marking have been stated.[46,47]

Surface techniques or methods

Over the years a large number of different surface techniques for marking of dentures has been presented:[21,23,48]

Engraving the casts

In this permanent marking technique the master casts are engraved with a dental bur or sharp instrument which creates a corresponding positive in the denture, but this is not often used because the positive marking in the denture leads to tissue irritation.[46]

Scribing or engraving the denture [49]

This relatively permanent marking of the denture can be done in several ways, for example by using a dental bur, knife or other sharp object, heat-producing fine point pen or by an electric engraving tool.

Writing on the denture surface

Several studies on pen marking of dentures have been carried out[21] which is done either by using a penetrating marking pen or by writing on the denture surface and covering the lettering with a clear Varnish,[50,31] In most cases, however, these systems cannot be considered as permanent as the inscription will wear out relatively quickly, but some very encouraging results using a graphite pencil and a home-prepared sealant have been obtained.[51]

Inclusion methods

In these techniques a label containing the information is included within the denture. The marker can be placed either in the tissue surface during trial packing or in the polished surface after processing, each offering both advantages and disadvantages.[47] The marker can be made of a variety of both non-metallic and metallic

materials and a short review of the more popular materials follows.

Non-metallic markers

A large number of different inclusion marker systems with non-metallic markers have been presented in the literature.[22] Commonly used marker systems are: writing with Indian ink on the acrylic dough,[52,53] printing on onion skin paper,[23] printing on adhesive label,[25] typing on nylon strips,[23] materials like linen and paper covered with acrylic,[54] light-cured resin[55] or fibreglass,[23] laminated polyethylene tape inscribed electronically,[24] and a new inclusion denture marking system[56] have been described. In the latter the author used foil prepared from the denture base resin itself resulting in good mechanical strength of the denture, good legibility as well as achieving an aesthetic marking. Other attempts to make invisible markings have been made with clear ink that fluoresces under ultraviolet light and using pink toilet tissue marked with a ball-point pen.[23]

Metallic markers

Metallic markers have been found to be the most durable form of marker in cases of severe conflagration. Subsequent research has shown however that the commonly used stainless steel ID-band which was tested and recommended[57] as early as 1963 did not fulfil the requirements of resisting 1300+°C for ten minutes, because at 1150°C the markings became illegible.[58] The search for a suitable alloy continues therefore to be addressed by several authors.[59-61] For example, the boron alloyed nickel - aluminide system[61] has been shown to withstand 1300°C for as long as 100 hours and the oxidation of the material resulted in an oxide layer less than two microns thick.

A cosmetically discrete way to mark dentures in which a small round heat-resistant micro-metal chip embedded in the denture and covered by clear acrylic has been described.[62,63] The authors claim that the chip remained intact and readable after burning for one hour at 1500°C. It should be noted however that other heat resistant and discrete methods to mark dentures have been previously mentioned.[64,65,66]

When using nickel-containing materials there is always a danger of allergic reactions. However, while this problem should not be ignored attempts to avoid Ni-containing materials such as stainless steel and nickel aluminides (that form stable protective oxides in atmosphere) for denture marks seem to be over-cautious and an over-reaction since the marker is well embedded in the acrylic and in all likelihood will never affect the body.[67] Stainless steel is of course a well established material for dental appliances and there is no documented case of it causing allergies, while even Ni-containing materials used in prosthodontics have been tested and found to have negligible effect.[68]

REQUIREMENTS FOR IDENTIFICATION MARKS

According to the "standards for identification" the requirements/criteria as oulined by the Council on Prosthetic Services and Dental Laboratory Relations[46,54,69] are the following:

- The strength of the prosthesis must not be jeopardised.
- It must be easy and inexpensive to apply.
- The identification system must be efficient.
- The markings must be visible and durable.
- The identification must withstand humidity and fire.
- The identification mark should be cosmetically acceptable to the wearer.

REGULATIONS AND RECOMMENDATIONS

In 1986 the National Board of Health and Welfare, which is the supervising authority on the health sector in Sweden, legislated and made it mandatory for all dentists to comply with the following requirements:[70]

The patient shall always be offered the opportunity to have his/her dentures marked with a personal number. In addition to the above the dentist shall always inform clearly and motivate the patient as to the benefits of the denture marking. This offer does not include small partial dentures which lack space for denture marking. The dentist, before delivering the denture, shall verify by referring to an identity card that the correct personal number is marked on the patientÌs denture. The denture marking may not be inserted if the patient refuses.

The personal number to be used will contain one letter and ten digits e.g. S-130904-1737 (S = Sweden, 13 = year of birth, 09 = month of birth, 04 = day of birth, 173 = birth number, 7 = control digit) all of which should not be less than 1.5 mm high. The printed or punched metal band should be incorporated into the base of the denture and covered with clear acrylic.

The regulations and the recommendations70 stress that the patient shall be offered the denture marking, and they replaced the earlier SOSFS 1980:91 regulation which was more prescriptive, that dentures must be marked if the patient does not disagree.

DISCUSSION

This review has pointed to the fact that many deceased persons in single accidents as well as in mass disasters could have been identified if their dentures had been marked,[1] and from an ethical point of view this is enough to justify the world-wide implementation of ID-marking of dentures. As has been mentioned previously, given that only one marked denture has led to the identification of a deceased when all other means have failed, makes denture marking worthwhile.[67] It has to be realised however that even if authorities such as The Swedish National Board of

Health and Welfare recommend denture marking the procedure and its quality can and will vary widely and some control has to be exercised. On the other hand there are ethical problems which inevitably occur in any possible infringement of the liberty of the individual. Some see a considerable threat in this, and they would perhaps consider identification of persons by means of artificial dentures to be in this category".[59] In a recent study of patients and dentists attitudes to denture marking in Sweden[45] it was found that very few persons had objections to ID-marking of their dentures. Previous studies by the group have shown that only few dentures are marked at manufacture in spite of wearers in Sweden and in the United Kingdom being in favour of having their mark on their dentures. The patients have even stated that they are willing to pay the cost of the marking.

There are different ways of marking dentures, but all should be reliable in leading to a correct identification. The use of social security number seems to be ideal because it is unique, while names, for instance, can recur and can be regarded as unreliable.

There is a strong need to adopt an international policy for denture marking and international collaboration should be encouraged, with different opinions from the world-wide community of forensic odontologists discussed, and with the aim of reaching some kind of consensus for the future. Borrman *et al.*[45] pointed out that ethical principles should be upheld in the legal establishment as well as in society since the socio-economics of denture marking might differ from one country to another. It is interesting, for example, that only 57% of dentists with forensic training knew about the recommendations regarding denture marking from the Australian Dental Association.[71] It should, however, be mentioned that already in 1972, in Mexico, the F.D.I. (Federation Dentaire Internationale) adopted a policy statement on denture marking "recommending to all member associations to introduce denture marking in their respective countries."

The authors suggest that dental associations and similar bodies should again seriously consider bringing the issue to the attention of governments and populations so that quality assurance programs also involve the issue of denture marking for clinical and forensic purposes.

Edentulousness will be found among the elderly well into the future and as a result the demand for denture marking will remain and it should be realised that the cost of marking dentures is minor when compared with the cost of replacing them[2] or the cost of extensive alternative forensic procedures to identify victims.

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ELECTRONIC DENTURE MARKING - AN AID FOR IDENTIFICATION

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INTRODUCTION

The number of edentulous people using complete dentures has been increasing worldwide, but in varying numbers in different countries and in 1990 for example, 80% of the population over 74 years in U.K. was edentulous. In cases of aircraft or ship accidents or natural disasters, denture wearers may be identified more quickly if their dentures were marked and it follows that all dentures should be marked.[14]

If there is the smallest suspicion that an unidentified person may be German, the German Federal Investigation Bureau (Bundeskrimkinalamt - BKA) is called into action through the German embassy in the country of the accident at great cost if the subject happens to be edentulous and without a marked denture.

In hospitals and nursing homes patients may lose their dentures through their own carelessness or the negligence of the personnel and retrieved dentures cannot be identified if an individual mark (i.e. at least a name of the owner) has not been inscribed on the denture. In their own surroundings and in cases of coma from diabetes mellitus, high blood pressure, myocardial infarction, nephrological diseases etc., elderly people with dentures may not be identified easily if their dentures are not marked. If they lose their dentures during the incident they will have to be remade because of a lack of a mark, once again at cost probably to the state. As the same age group now tends to travel much more (27 million Germans each year are travelling into high risk regions), the risk of their being involved in a transport accident is much higher.

In 1972 during the 60th World Congress[15] of the Federation Dentaire Internationale (F.D.I.) recommended the marking of all dentures. As early as 1977 the German Association for Forensic OdontoStomatology (AKFOS) recommended this procedure as one of their ten main targets. Some states of the USA have legislated the mandatory marking of dentures mostly by names or initials and/or insurance numbers for two purposes.

1. Older residents should wear marked dentures to help with their or their dentures' identification, and
2. In DVI where marked dentures will greatly assist identification.

In 1993, Texas and Wisconsin introduced a law that made the marking of dentures mandatory, and North Dakota, Ohio and Alaska use special regulations for denture marking. Altogether, 21 states of the USA strongly advise their dentists to mark dentures. Some other states of the USA expect that dentures are marked for people in long-term institutional care.[6]

In Sweden, all dentures are to be marked, while other countries use denture marking for special groups.[1,9] A report from Sweden discloses that in 1992 in well over 1400 forensic odontological cases 19% of the dentures were marked.[12] In a study of long-term patients in Gothenburg[8] 64% of the persons were edentulous; 64% of these wore correctly marked dentures.

In the same country[3,5] dentures are marked on a thin Ni-free, stainless-steel band* by typewriter, containing the name and personal ID-number used in that country (Fig.1). Nordell *et al.*[7] used a non-allergenic NiAl rich alloy (Al_2O_3, $NiAl_2O_3$) embedded in the acrylic denture base and resistant to temperatures of up to 1300°C for 10 min.

Fig. 1 *Model marked by an ID band*

In the former GDR[4] 568 patients were provided with a 0.03 mm-thin Cr-Ni-foil marker, in which the personal ID-number was imprinted by typewriter; and in addition the birth date, a gender code and the address were added. In a follow up study between four weeks and a year later, only 10% of the marked dentures showed any surface defects from tartar, smoking residue or laboratory defects.

Denture markers should resist high temperatures for 10 minutes and remain unharmed during that period, they should be biologically inert, and they should not be contaminated by saliva. They should be cheap, easy to process and visible.[7]

Surveys among patients in Germany by the author (KR) from 1977-1997 on the other hand showed that a vast majority of the persons offered denture marking with a number/letters or their names, which were open to public

* *UD-Band, Remanit*

view, rejected it. Microchips or other marks that cannot be seen or read publicly, however, were acceptable. A prominent privacy commissioner has written in the press that "there are no problems using the chip, if only basic data are included (name, insurance number)".[10]

The use of microchip** 4 x 4 x 1 mm inserted into a complete upper denture is presented.

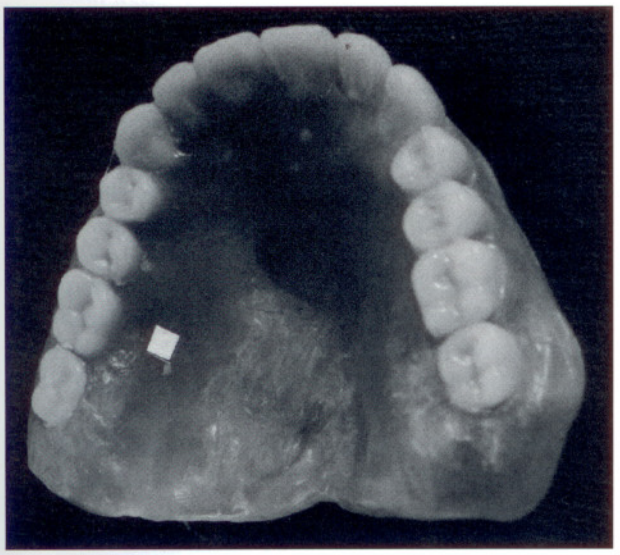

Fig. 2 Model marked by a memory chip

MATERIALS AND METHODS

Description of the system

Hardware
Hand-held PSION† workabout (128k Flash SSD including software, 2 batteries Rc Alkaline 1.5V or NiCd-storage batteries R6 1.2 V/700 mAh), the read/write pen (PEN 232 standard) for data transfer to PC or solid-state disc (when a PC is used, the hand-held PSION workabout is not required) and a MEMORY-chip.

Software
The program PROTHEI.OPO†† as well as the database file PROTHEII.DBF to initiate the data is installed on the internal RAM drive of the mobile hand-held device. Safety copies of both programs are in a 128k Flash-Rom and may be copied onto the internal disk drive. To avoid computer crashes it is advised regularly to make safety copies of the database file PROTHEII.DBF.

Application

Visible installation into the denture, sealed by clear acrylic resin. Data-transfer is effected enbloc without direct contact by using the pen and network storage of the data is in a PC, laptop or hand-held.

Data-management
Information of the patient
Field information: Surname, first name, insurance number
Data security: PIN, Information kryptographed

Requirements

The patient's agreement and ability to pay for the marking (nearly DM 20, approx. US $10).

RESULTS AND DISCUSSION

A survey of 1,200 dentists and 639 patients concerning their opinions of denture marking[13] was performed by the Institute for Medical Statistics and Documentation in Mainz (Germany) and showed that 67% of the dentists had no objections to denture marking, whereas 24% had the following doubts: problems with technical aspects, costs, patients' agreement, abuse by unauthorized persons. Only 9% of the dentists were against any marking (too much paperwork, confusion in their own surgeries; usefulness bears no relation to expenditure).

Every dentist's questionnaire included patients' questionnaires with the following questions:
1. Would you agree to the marking of your denture?
2. Would you be ready to pay part of the expenses?

The result was that 92% wanted a marking and 64% were ready to pay for it.

A year later, a repeat survey showed that 80% of the dentists had no objection to denture marking, 17% had some doubts, and only 3% were against it. Ninety four percent of the patients were now for it, only 6% against, 67% were willing to pay part of the expenses, while 33% were against paying for it.

In Sweden, a survey in 1995 among 114 dentists and 204 patients,[2] showed that a majority agreed to a marking.

It is obvious that very few edentulous people with marked dentures will become victims of fire accidents and indeed only a relatively few cases are reported in the international literature. It is however still necessary to support. The marking of dentures, but this must be done in a simple, cheap and accessible method using modern technology, because dentures can be marked not only with conventional inscribed metal strip markers, but also with microchips embedded in the denture, and as described in this paper this could fulfil most requirements of a denture mark, including privacy.

The initiation of an international cooperative effort in the field of denture marking has been proposed in which different approaches on this subject, taking national and cultural principles into consideration will be exchanged. The German Association for Forensic Odonto-Stomatology (AKFOS) hopes that this article has provided some thoughts which may stimulate further discussion.[11]

** *microSensys*
† *Psion Industrial PLC 1996, London, England*
†† *Micro Sensys GmbH, Juri-Gagarin-Ring 27, D-99084 Erfurt Germany*

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