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DENTURE IDENTIFICATION: A NEW BAND MATERIAL AND THE SWEDISH ID-BAND REVISITED

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ABSTRACT

The Swedish-developed ID-band has become the internationally accepted method for marking dentures and the Federation Dentaire International (FDI) has put its stamp of approval on the system, but recent research has indicated that the materials used for the metal bands are not resistant to the temperatures the material might be exposed to during fire. In this article, a new group of materials (nickel aluminides) is shown to have a unique combination of mechanical strength, ductility, microstructural high temperature stability and high temperature oxidation resistance in both oxidising and carbonising atmospheres, that make the material suitable for denture marking. **(J Forensic Odontostomatol 1997; 15: 23-26)**

Keywords: denture marking, forensic odontology, identification, nickel aluminide

INTRODUCTION

The Swedish-developed ID-band* has become the internationally accepted method for marking dentures and the Federation Dentaire International (FDI) has put its stamp of approval on the system. Recent research[1] has indicated, however, that the metal bands accepted by the FDI for denture marking are not sufficiently resistant to high temperatures. Aspects of the selection of materials for denture marking have been investigated by Thomas *et al.*[2] and we suggest that new materials should be sought and further tested. As stated in a previous paper[3] "from a forensic point of view, it is necessary to find and use the most suitable ID marking band for dentures which has both clinically and technically acceptable qualities". During a fire the denture is usually protected from high temperatures by the soft tissues of the face and the tongue. Previous publications have reported that dentures are often propelled from the mouth of aircrash victims[4,5] where there could also be destruction of the jaws in a subsequent fire. It is also important from a forensic point of view to know that a number of denture wearers could be identified among victims of a mass disaster if the dentures were marked. This issue has been discussed in a paper by Andersen *et al.*[6]

In Sweden dentures issued to patients were initially fitted with identification bands made of ordinary soft stainless steel (18Cr 8Ni) that could easily be marked with an ordinary typewriter. Later this product was changed to a Ni-free steel for fear of allergy. However, it is a fact that allergy problems from stainless steels incorporated into dentures are negligible.[7]

The ID-band was marketed with an explicit claim that it withstands a temperature of 1300°C for ten minutes in accordance with the FDI regulations. This proved to be incorrect as found in a study on temperature resistance of different types of metal bands for ID marking[1] which showed that the three different types of steel bands used in Sweden were not legible after exposure at 1200 and 1300°C and only one of them after exposure at 1100°C for ten minutes. This was not unexpected since most stainless steels deteriorate from catastrophic oxidation (i.e. scaling) in a carbon and oxygen rich atmosphere at temperatures in the range of 850-1100°C.

Although investigations and reconstructions after the Scandinavian Star ferry accident in 1990 by the Norwegian State Committee showed that the temperature probably did not reach 1000°C[8] the exact temperature in a fire is difficult to estimate. This fact, in combination with the statement made by the manufacturer of the ID-band that it resists temperatures of 1300°C for ten minutes, indicates that it is necessary to find alternative materials with higher corrosion resistance and better microstructural stability at high temperatures.

The aim of this article is to present a newly developed group of materials, nickel aluminides, that might be considered as a strong candidate for denture marking and to investigate the oxidation properties and microstructural stability of a ductile boron alloyed nickel aluminide in both air and carbonising environments at elevated temperature up to 1300°C.

MATERIALS

Nickel aluminides are a relatively new group of alloys based on intermetallic phases.[9,10] The alloys possess many promising properties such as good mechanical strength both at room and elevated temperatures[9] and very good high temperature oxidation resistance, the latter because of their ability to form Al-rich, protective scales (Al_2O_3, $NiAl_2O_4$).[11] Even if the material contains Ni,

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there should not be any problems with Ni allergy since the material is encapsulated in a polymer and the material is passive in solutions that range in pH from four to approximately ten.[10] This passivity is the result of reaction with water to produce a stable aluminium oxide or hydroxide film on the surface of the material.[10] The aluminium reaction film acts as an effective diffusion barrier to ionic species of the alloying elements. A major drawback, however, is that nickel aluminides usually have a low room temperature ductility[12] and the main reason for this is its polycrystalline structure with weak grain boundaries. Another reason is environmental embrittlement where water vapour reacts with Al at grain boundary cracks and the generated hydrogen diffuses into the bulk metal causing brittle fracture.[13] However, in 1979 Aoki *et al*[12] showed that microalloying of nickel aluminide with boron radically increased the room temperature ductility from 3% without boron to a maximum of 50% with 0.1 wt.% boron. There are two mechanisms that explain this:

1. Boron which has a strong tendency to segregate to the grain boundaries, enhances the grain boundary cohesion and
2. The boron at the grain boundaries occupies the same lattice sites as hydrogen and thus prevents hydrogen from penetrating into the bulk of the material.

METHODS

The chemical analysis of the boron-containing alloy used in this study is shown in Table 1. The material was cast in copper moulds at the Royal Institute of Metal Research, Stockholm and the ingots were then defect-healed by hot isostatic pressing at 1150°C for 3h. Samples, 10x20x3mm,[3] were cut from the ingots and ground and polished down to 1 micron diamond paste.

To investigate the oxidation behaviour of the material, samples were heated to 900, 1100 and 1300°C (in air) for 12h at a rate of 6°C/min in a thermogravimetric analyser (TGA) and the weight gain was continuously registered until isothermal conditions were reached. The samples were weighed on an analytical balance before and after the TGA measurements.

In addition the material was exposed to a carbonising corrosive environment ($1\%CH_4 + 99\%H_2$) at 1100°C for 50 and 100h to examine the influence of a carbon-containing atmosphere on the high temperature corrosion behaviour and stability of the microstructure. In these experiments the heating time from room temperature to 1100°C was 8h. The oxygen partial pressure in these experiments was measured by a zirkonia probe to 6x10-20Pa, which corresponds to a partial pressure of H_2O, p_{H20}, of 14Pa.

X-ray diffraction (XRD) was performed on the surface products to determine the structure and surface analysis carried out with Auger electron spectroscopy (AES) and X-ray photoelectron spectroscopy (XPS). The microstructural analysis was performed by scanning electron microscopy (SEM).

Ni	Al	B
Balance	23	0.2

Table 1: the composition in atomic % of the material used in the study (the chemical analyses were performed by Sandvik Steel).

RESULTS AND DISCUSSION

The isothermal oxidation in air at 900, 1100 and 1300°C is shown in Fig.1 (oxidation products included). The results of the weighing of the samples before and after the TGA are presented in Table 2, the differences in weight gain likely to be due to oxidation growth during heating and cooling. The material shows excellent oxidation properties except at 1100°C where the weight gain is even higher than at 1300°C. However, XRD shows that the dominant surface product at 1100°C is NiO instead of dense protective Al_2O_3 which might explain the poorer oxidation resistance at 1100°C.

Temperature (°C)	Weight gain (mg/cm^2)
900	0.40
1100	1.40
1300	1.10

Table 2: Weight gain due to oxidation in TGA in air for 20h.

The overall analysis of the surface region of the material after the thermal treatment is shown in Table 3.

In the carbonising environment a weight gain of only 1.2mg/cm2 was measured after 100h of exposure and as can be seen on the micrograph in Fig.2 the material shows a smooth almost unaffected surface with sharp grain boundaries.

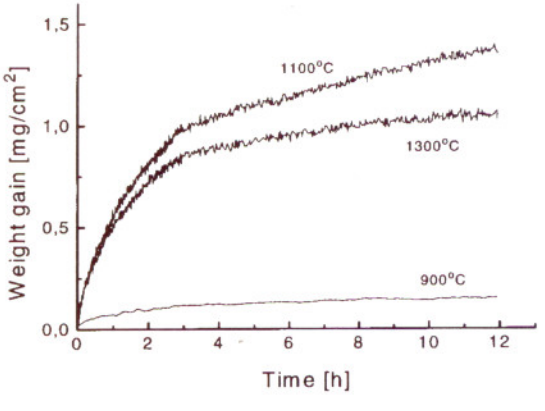

Figure 1: Weight gain against time for oxidation in air at 900, 1100 and 1300°C. Oxidation products included.

Temperature (°C)	Region (analysis method)	Analysis results
900	Surface (XPS)*)	Ni (16.5%), Al (16.5%) O (67%)
	Calculated oxide thickness	0.75µm
1100	Surface (XPS*)	Ni (29%), Al (13%), O (58%)
	Calculated oxide thickness	2.6µm
	Internal oxidation (AES**)	None
1300	Surface (XPS*)	—
	Cross section (SEM ***) surface oxidation	Surface oxide ≈ 2µm
	Internal oxidation (AES**)	None

* X-ray photoelectron spectroscopy.
** Auger electron spectroscopy.
*** Scanning electron microscopy.

Table 3: Results from AES and XPS after oxidation in air for 20h.

Temperature (°C)	Region (analysis method)	Analysis results
110	Surface (AES*)	Thin (30nm) Al_2O_3 oxide. No carbides detected.
	Surface (XRD**)	Ni_3Al. No carbides detected.
	Cross section (AES*)	Bulk material. No carbon.

* Auger electron spectroscopy.
** X-ray diffraction.

Table 4: Results from AES and XRD analysis of the material carbonised in 1%CH_4 + 99%H_2 for 100h at 1100°C.

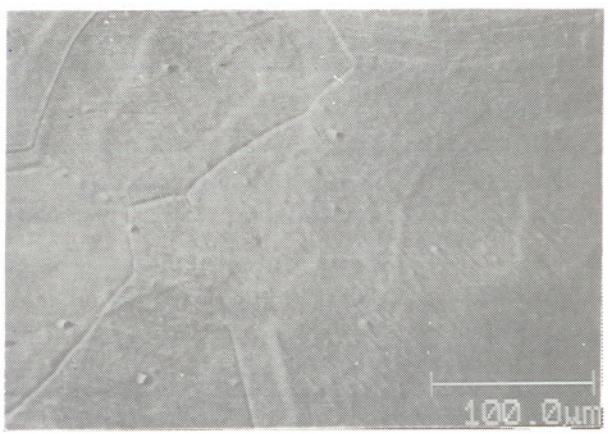

Figure 2: The surface of the material after exposure in 1%CH_4 + 99%H_2 at 1100°C for 100h.

AES depth profiling after exposure in 1%CH_4 + 99%H_2 at 1100°C for 100h showed that the surface, in spite of the fact that the measured partial pressure of oxygen was very low, was covered by a very thin (about 30nm) Al_2O_3 film. No SEM visible carbides were formed during the exposure but the material increased its carbon content without forming carbides and after the treatment the content of dissolved carbon in the material became 0.28wt.%. The AES and XRD measurements on the material after exposure is summarised in Table 4.

CONCLUSIONS

The oxidation tests performed in both air and carbonising environment (1%CH_4 + 99%H_2) showed that boron-containing (0.2at.% B) nickel aluminide has extremely high temperature oxidation resistance and microstructural stability up to 1300°C even at long exposures (up to 100h). This, together with the good mechanical strength and the high room temperature ductility of the material obtained by the microalloying with boron, makes this material an excellent potential choice for a denture marking identification band.

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THE ORAL HEALTH STATUS OF DRUG ADDICTS. A PRISON SURVEY IN LILLE, FRANCE

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ABSTRACT

The purpose of this study was to describe the prevalence of decayed, missing and filled teeth among the inmates of the jail of Loos (France) and to assess the impact of drug addiction, especially heroin, on these parameters of oral health. A representative sample was selected and two groups were compared: heroin addicts and non-drug addicts. The same dentist examined 93 inmates, males and females, from age 16 to 35. The results found a significant difference of DMFT index between the groups, with a higher value of DMFT for the heroin users. This investigation also highlighted atypical caries lesions among the heroin addicts. **(J Forensic Odontostomatol 1997; 15: 27-29)**

Key words: caries, prison, heroin

INTRODUCTION

Dentists should be anticipating more frequent contacts with drug addicts because of the increase in drug abuse and the improvements in rehabilitation health services which allow for closer monitoring of the health, including oral health, of addicts. Several investigators have noted the high prevalence of dental caries among different prison populations,[1-3] and the role of heroin in the deterioration of oral health, and in dental caries in particular, has been alluded to.[4-9] The quantification of the state of the dentition[5] using the decayed (D), missing (M), filled (F), teeth (T) (DMFT) index is comprehensive, easily applied and widely used in dental health programs. The aim of this study was to investigate the prevalence of DMFT index in a prison population of heroin addicts and to compare it with a similar non-drug addict population.

METHODS

The prison of Loos is a state institution where the daily average population consists of about 1100 men and 120 women. During the incarceration period the inmates are advised of how to obtain dental care by submitting a written request through physicians, nurses and other staff. Ninety-three subjects were included in the study to determine this DMFT index. Two subgroups of inmates less than 35 years-old were constituted, heroin addicts and the non-drug addicts respectively. The criterion to be included in the first group (N=47) was an active or former heroin addiction and the criterion to be included in the other (N=46) was no history of addiction. Edentulous subjects were excluded and the characteristics of both groups are described in Tables 1 and 2.

	heroin addicts		non-drug adicts	
Age intervals	**N**	**%**	**N**	**%**
16-20	3	6.5	11	24
21-25	23	49	10	21.5
26-30	18	38	15	33
31-35	3	6.5	10	21.5

Table 1: Comparison of characteristics of the heroin addict and non-addict subjects.

	heroin addicts		non-drug adicts	
Sex	**N**	**%**	**N**	**%**
Males	31	66	38	83
Females	16	34	8	17

Table 2: Gender ratio in both heroin addict and non-drug addict groups.

A dentist examined the inmates, recorded findings on a standard form and took care to ensure that all data were recorded according to prison identification codes to maintain inmate anonymity. The oral examination was performed with mirror, explorer and adequate illumination and radiography was not used. The examination determined the status of 28 teeth (third molar teeth were excluded) and the inmates included in the heroin addicts group were interviewed about the duration, in months, of heroin addiction and about the method of administration (intravenous or by inhalation).

The mean and standard error of the mean were calculated for each group and the significance between means was evaluated using a Student's t test with p less than 0.01 regarded as significant.

RESULTS

We examined 93 subjects and Table 1 shows the characteristics of the two groups. The mean age of the studied population was 25 years, the mean age of the heroin addicts group was 25.2, the mean age of the non-drug addict group was 25.9 and there was no significant difference between the two. The groups contained 69 males and 24 females with no significant difference for the DMFT index according to gender (Table 2).

The dental and oral health profiles of the two groups are presented in Tables 3 and 4. Results clearly show that the DMFT index rises according to the age of the subjects, except for the 31-35 year age-group of the heroin addict group. The data in Tables 3 and 4 demonstrate that DMFT index is also statistically significantly higher in the heroin addict group than in the non-addict group ($p<0.005$). Data show that the difference in DMFT index is correlated with a significant difference of the decayed teeth in the two groups ($p<0.01$) although no significant difference was found between the missing or filled data.

The mean duration of heroin addiction was 52 months (range: 2-196) and the method of administration of heroin was by inhalation exclusively in 57.5%, injection exclusively in 19% and a combination inhalation and injection in 23.5%.

DISCUSSION

Studies in the general (non-prison) population show a significant difference of DMFT index between drug and non-drug addicts[6,7] although this has not been found in a prison population.[4] On the other hand, the effect of heroin on the dental structures has been reported.[4,8,9] Following on these data, we have investigated the prevalence of DMFT index in a prison population comparing heroin addicts and non-drug addicts.

Both groups were comparable in age, gender and socio-cultural composition and to maintain comparability, and because the mean age in the drug addicts is very low, we excluded people over 35 years. As a result no significant difference in each class of age was found between the groups. The number of females appears very low but the gender ratio in both groups is consistent with the total population of the prison and no significant difference is found in comparing the gender parameter between groups. To estimate the DMFT index, wisdom teeth were excluded because of their variability.

Age intervals	D		M		F		DMFT	
	H	NA	H	NA	H	NA	H	NA
16-20	6.33	2.72	2.33	0.72	0.66	2.36	9.33	5.81
21-25	5.65	5.80	2.60	1.20	3.43	2.50	11.65	9.50
26-30	7.50	4.20	3.66	2.46	4.05	3.33	15.22	10.00
31-35	11.3	3.40	1.33	4.90	0.66	3.50	13.33	11.80

H = heroin addict group
NA = non-drug addict group

Table 3: Means of decayed, missing, filled teeth according to age.

	D	M	F	DMFT
heroin addicts	6.76 (5.23)[a]	2.91 (2.61)	3.29 (3.05)	12.98 (6.04)
non-drug addicts	4.02 (3.99)	2.30 (3.08)	2.95 (3.47)	9.28 (6.29)

a = standard deviation

Table 4: Means of the DMFT index in both heroin addict and non-drug addict groups.

Authors who have studied the DMFT index in non-prison populations describe a great difference between drug addicts and non-addict groups.[6] This could be explained by the fact that in general populations the subjects are concerned with oral health and routinely seek dental care whereas subjects within drug addict groups are usually selected from rehabilitation centres and, as could be expected, differ in their motivation regarding health and socio-economic factors. These differences could influence the results observed by these authors.

On another hand, studies performed in prison populations do not show any difference of DMFT index between drug and non-drug addicts.[4,8] In this type of population the two groups are more comparable because most of the inmates, drug addicts or not, have never visited the dentist because of either neglect, lack of social assistance or a lack of health education, and none of these surveys reports specifically the types of narcotic used.

While the role of heroin in the incidence of caries has been reported[4,8,9] this study has investigated the DMFT index among inmates between two groups: incarcerated heroin addicts and non-drug addicts. Our results clearly show a significant difference in the DMFT index with higher figures in heroin addicts. This difference seems to be linked with the incidence of caries. When each parameter of the DMFT index is studied separately however the difference is only significant for decayed teeth and is not significant for missing or filled teeth. The contribution of heroin in the increase of caries is assumed but there is no indication of its actual pathogenic properties. However, when incarcerated, the narcotic addict has to endure withdrawal symptoms and the reactivation of the dental pain and discomfort normally masked by the effect of the drug. The subject often has to wait for a trial and in this stressful period neuroleptic and tranquillising therapy has to be administered which induces xerostomia and promotes further carious lesions. Many addicts are furthermore heavy users of candies, cakes and sugar which naturally also enhances the risk of caries.

Surprisingly we noted that most of the detainees included in the heroin addict group used the inhalation method rather than injection which could be the result of the successful French preventive measures aimed at reducing the transmission of viral diseases. The increased values of the DMFT index and the duration of addiction could not be linked.

During the oral examination of the addict group we found many of the atypical carious lesions previously described by Lowenthal[8] on the labial buccal surfaces of the teeth. They seemed larger, darker and less painful than usual cervical caries and previous authors[8,9] have stated that these lesions are pathognomonic and could be considered as an aid in identifying the narcotic addict. Our conclusions are in agreement with these authors.

CONCLUSION

The purpose of this study was to investigate the relationship between narcotic addiction and the state of oral health of prison inmates. Results show an increase of DMFT index in the heroin users suggesting a role for heroin in the cause of caries. Some complementary studies would be necessary to confirm these data and to identify further the effect that drug addiction has on dental and oral health. Such a study is underway in this Centre in Lille.

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DENTURE MARKING: A QUESTIONNAIRE FOR PATIENTS AND DENTISTS

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ABSTRACT

It has been recommended by the Swedish National Board of Health and Welfare (NBHW) (SOSFS[M] 1986:25) since the 1960s that all patients should be offered the opportunity to have their dentures marked. The Swedish ID-band has become the international standard and the FDI-accepted denture marking system. Recent research from our group has shown that only about 50% of the dentures in homes for elderly were marked. Since this is not acceptable the aim of this study was to investigate the opinions regarding denture marking among dentists, dentate patients and edentulous patients.

The results from this study are based on the answers from 79 dentists. Most dentists made 2-5 dentures a year and in only four cases had they experienced unmarked dentures returning from the dental technician. Most of the patients were satisfied with their dentures but sixteen were not. According to the patients their dentist did not ask for permission to mark in 76% of cases and the dentists stated that they did not ask for the patients' opinion about marking in 65% of cases. One of the conclusions from this investigation indicates that the dentists are responsible for the lack of marking of the dentures. Previous studies have shown that denture marking can be crucial in identification of deceased persons and that clinical experience shows that denture marking is important especially in institutions where the recommendations of the NBHW should be stressed. **(J Forensic Odontostomatol 1997; 15: 30-36.)**

Keywords: Forensic odontology, identification, denture marking

INTRODUCTION

A denture is only of value in identification if it is properly marked and only then it can be equivalent to teeth for that purpose.[1] The marking of dentures is not regulated by law in Sweden, but it has been recommended by the Swedish National Board of Health and Welfare (NBHW) since the 1960s with the latest recommendation issued in 1986.[2] It stated that all patients should be advised to have their dentures marked with an identity number, but which they are free to refuse. It must however be assumed that patients rarely refuse to have their dentures marked since Johanson and Ekman[3] have not experienced any such refusal. Furthermore, according to Karlsson,[4] no denture leaves one of the largest dental laboratories (HMK) in Göteborg without being marked and other dental laboratories in Sweden have reported the same.[5] In contrast to this, Bengtsson *et al.*[5] found only about half (47%) of the dentures in homes for elderly were marked and this is in accordance with the results of an analysis of forensic odontological cases from Göteborg.[6] Recent information from Stockholm, Sweden has revealed that only about half of the dentures are marked.[7]

Denture marking needs to be seriously addressed at international level since the frequency of denture marking has been reported to be as low as 2.5%.[8] It should also be mentioned that in Britain about 80% of all people over the age of 65 years were found to be edentulous[9] and of the 50 persons who died in the Bradford city (UK) football club fire in 1985 nineteen wore dentures but only one was marked. The identification of the victims would have risen from 45% to 82% if the dentures had been marked.[8]

In a survey by Andersen *et al.*[10] the importance of denture marking in the identification of deceased persons was emphasised. They studied 292 fires from four centres of forensic odontology in Scandinavia (DK: Aarhus and Copenhagen; N: Oslo; S: Göteborg) covering a 10-year period (1982-1991) and found that only one denture was marked. Reconstruction of available information regarding the cases revealed that 25 of the victims would have been identified by dental means if their dentures had been marked. It has to be realised however that a denture *per se* does not prove identity since it is not a fixed appliance but it is a significant link in a chain of evidence of personal identity.

In a recent survey performed by Community Dental Care in Göteborg[11] on the dental condition in 1500 patients in 12 homes for the elderly it was found that only 35% of the 1082 dentures (complete upper and/or lower dentures) were marked, with the results being very variable for the different homes. The results of this survey are not satisfactory and will be dealt with by Community Dental Care as a part of the quality regimen in dental care. Marking of dentures is important not only for forensic reasons but also for identifying the dentures, for example when they are inadvertently lost, during cleaning, if placed on a food tray and then carried away or in cases of unconsciousness or loss of memory.

It would be interesting to know whether the non-marking of dentures is due to resistance among patients and/or dentists or if there could be other reasons. The aim of this study was therefore to investigate the attitudes of patients and dentists regarding denture marking.

MATERIALS AND METHODS

Denture Marking

In accordance with the instructions from the Swedish National Board of Health and Welfare:[2]

1. All patients with removable dentures shall be offered a denture marking.
2. In connection with the offer to mark the dentures, the dentist shall inform and motivate the patient about the marking.
3. The offer of marking shall not include small partial dentures where there is not enough space to hold the identification band.
4. Before the patient receives the marked denture, the dentist shall ensure that the marking is correct i.e. that the identification number written on a legal identification document (drivers licence, passport, etc.) is the same as the number which is written on the denture.
5. Marking of dentures cannot be done if the patient refuses to agree to it.

Dentists

A random sample of 114 dentists in the southern part of Sweden (supervision area of the regional office of the Swedish National Board of Health and welfare in Malmö) was evaluated. Thirty-seven of the dentists were dental officers in the Public Dental Health Service and 77 were private practitioners. Some of the questions were not answered by all dentists.

Patients

The patients (n=204) involved in the investigation were treated at the Public Dental Health Service in Malmö and in Båstad. The patients were divided into two groups, those who were wearing some kind of prosthesis (n=85) and those who were not (n=119).

The questions to the dentists and to the patients are listed in Appendix 1.

RESULTS

Answers from dentists

A total of 114 questionnaires was sent out and 87 (76%) of the dentists responded. Eight did not do any prosthodontic work and the results were therefore based on the responses from 79 dentists. The results of this study can be seen in Figs. 1 to 6 and in Tables 1 to 3. The majority of the dentists had been working between six and 35 years at the time of their replies (in 1995) and one dentist did not answer this question. Most dentists (n=34) made two to five complete dentures a year (Fig.1) while 12 dentists made more than 10 complete dentures a year.

Five of the dentists did not answer the question "For how many dentures did you request a marking?" whereas the majority of the dentists (n=68) said that in 81-100% they asked for marking of the dentures and five dentists requested it in 0-20% of the dentures. One person estimated that he asked for marking in 61-80% while four dentists (5%) had experienced unmarked dentures even if marking was requested. The opinions regarding denture marking are presented in Table 1.

The question "Does it happen that the patient does not accept denture marking?" was not answered by seven of the dentists (Fig.2). Nine dentists had experienced

	Number of dentists
Marking is routinely carried out	6
Marking is done for forensic odontological reasons	3
Marking is done to avoid misplacement in homes for the elderly	1
No marking if:	
– patients refuse to have it	5
– not enough space on partial dentures	4
– partial dentures	1
No answer	60

Table 1: The answers from the 79 dentists to the question regarding the reasons (one person stated more than one reason) for not marking or marking the dentures.

	Number of patients
Resistance to registration	7
Not aesthetic	5
No wish to be identified as denture wearer	1

Table 2: The patients' reasons for not accepting marking reported to the dentists (some patients stated several reasons).

	Number of patients
To increase the possibility of identification	23
To avoid mix-up of the dentures	12
Yes, why not	4
Yes, not a disadvantage	3
Yes, important	2
Yes, for safety reasons, of course, must make things more simple	5
Yes, nothing to hide, OK	2
Yes, I do not understand what problem there could be	1
No, I am tired of personal identification numbers	1
No, my teeth do not belong to the state	1
No, if I loose them I will buy new ones	1
No answer	66

Table 3: The 119 patients' own opinions about denture marking (some of the patients stated several reasons).

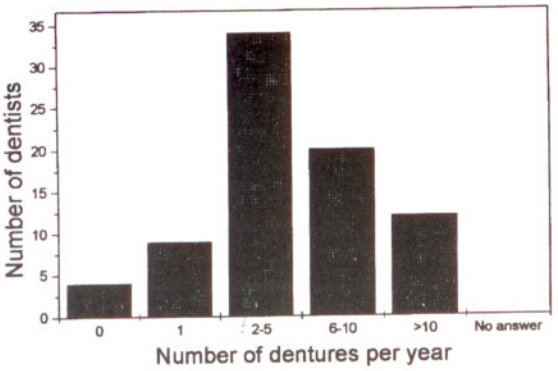

Figure 1: Question (#2 in the questionnaire) to the dentists. How many dentures do you make per year?

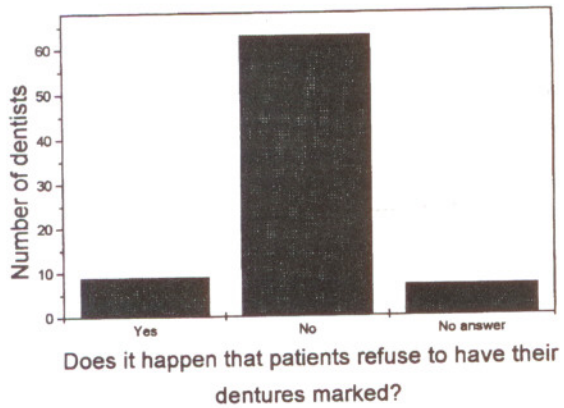

Figure 2: Question (#9 in the questionnaire) to the dentists. Does it occur that the patient would not accept denture marking?

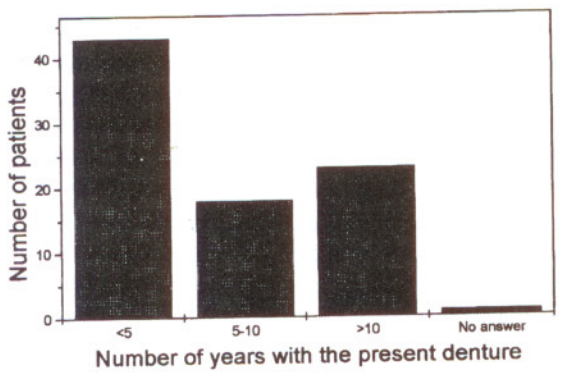

Figure 3: Question (#2 in the questionnaire) to the denture wearers. When did you get the denture that you are wearing now?.

patients not accepting the marking while 63 dentists had not experienced any refusal. The patients' reasons for not accepting marking of their dentures are presented in Table 2.

All except one of the dentists stated that 81-100% of the complete dentures made in their practices were marked with the patients personal number and the remaining one stated that 61-80% of the dentures were marked. Three dentists did not answer this question. The question regarding the proportion of unmarked dentures among the total number of dentures that the dentists dealt with in their practices gave a range of answers but the majority said it seldom occurred (i.e. 40% of the dentists experienced only 0-20% unmarked dentures). Less than 10% of the dentists saw 61-100% unmarked dentures and 14 of the dentists (18%) did not answer this question.

Fifty-one of the dentists did not ask for the patients' opinions about marking of their dentures, 13 dentists always asked and 11 sometimes asked. Four did not answer the question.

Answers from denture wearers

Eighty-five patients received and answered the questionnaires during their dental visits and about half of them had their present dentures for more than five years (Fig.3).

Twenty-five patients said that their dentures were marked, 56 stated that their dentures were unmarked while three stated that they did not know. The majority of the patients (n=65) reported that the dentist did not ask for permission to mark their dentures; only six had done so (Fig.4), while 14 of the patients did not know the answer to this question. Sixty-nine of the patients were satisfied with their dentures and 16 were not.

Answers from non-denture wearers

All patients (n=119) in this group, i.e. those who did not have any dentures, answered the questionnaires. The great majority (n=101) reported that they would allow marking of a future denture while 5 said "no" and 13 patients stated that they did not know (Fig.5). The patients were also asked to explain why they wanted their dentures to be marked. Some of the patients (n=55) who gave a motivation to their answer mentioned more than one reason for marking the dentures (Table 3).

Another question was: "What kind of treatment would you prefer to get if you were asked to choose between dental implants (fixed teeth) or an ordinary denture (removable)?" Only one patient did not answer this question and five patients did not know. Ninety-four patients preferred an implant and 19 of the patients wanted a removable denture.

DISCUSSION

Dentists

The sample of 114 dentists in this study from the southern part of Sweden cannot of course be representative of Sweden as a whole, but the results show that the recommendations of the NBHW are not being complied with. The age distribution of the dentists in this study was similar to the mean ages of dentists in Sweden and it seems as if the dentists in this investigation make a similar number of dentures to the average dentist in Sweden. The mean number of complete dentures in 1994/95 was 2.2 and the mean number of both partial and complete dentures was 4.9 (National Board of Insurance statistics). Since there was an uneven number of dentists representing

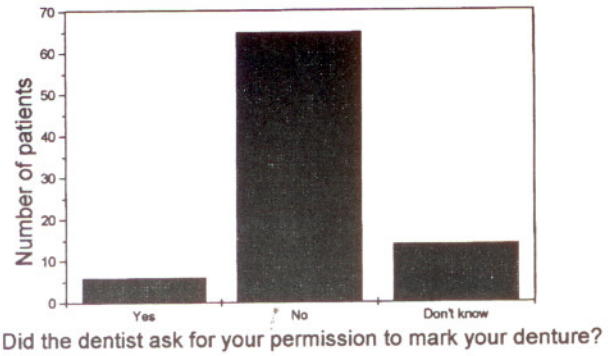

Figure 4: Question (#4 in the questionnaire) to the denture wearers. Did the dentist ask for your permission to mark your denture?

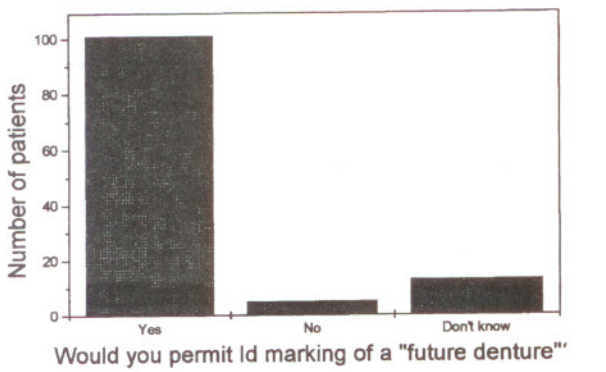

Figure 5: Question (#1 in the questionnaire) to the non-denture wearers. If you were to get a denture in future, would you permit it to be marked with your personal number?

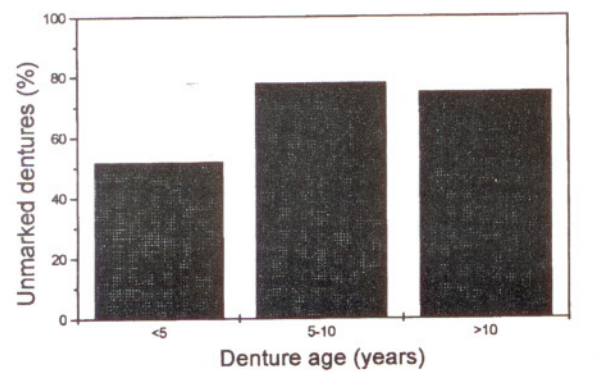

Figure 6: Age of the dentures and incidence of denture marks (the Swedish National Board of Health and Welfare recommended denture marking in 1986).

public dental care only the overall results are discussed, as the aim of this study was not to study possible differences between private and public dental care. Thirty-seven of the dentists were dental officers in the public dental health service and 77 of the dentists were private practitioners. There was also a difference regarding the frequency of answers to the questionnaires among dentists in private and in community dental care since 21 private practitioners and six dental officers did not answer the questionnaire. Since the purpose of this investigation was not to study differences between private and public dental care and since the numbers are small the conclusions should be viewed with caution.

Questionnaire

The number of dentists who answered the questionnaire was high and they found that almost all dentures are marked. In spite of this they did encounter unmarked dentures in practice and the question must be asked: where do they come from? One obvious reason would be that they are old but, this is not in accordance with the findings in this study where 50% of the dentures were less than five years-old. A difference related to denture age was however observed with about 50% of the dentures that were less than five years old being marked whereas almost 80% of the dentures that were 5-10 years-old were unmarked. Similar numbers were found for the dentures that were older than 10 years (Fig.6). It has to be realised that the implementation of recommendations affecting society as a whole can be a slow process and this could partly explain the high number of unmarked dentures (65%) found. Another explanation could be negligence on the part of dentists which could be in accordance with recent data from homes for the elderly in Göteborg[11] where too many dentures were unmarked whereas, in fact, all dentures made after 1986 should have been marked.

Some dentists seemed to have misinterpreted the definition of the word "denture" and thought it referred also to removable partial dentures (RPD) and this was evident from the answers to the question regarding the reasons for marking or not marking the dentures. One reason for not marking dentures could have been that there was not enough space on the RPD for placing the identification strip according to four of the dentists. Furthermore, one dentist said that he did not mark RPDs. In future, it will be necessary to define the word denture and in all communications use the words complete dentures, maxillary/upper denture and mandibular/lower denture in order to avoid misunderstanding. According to the instructions from the Swedish National Board of Health and Welfare all dentures including RPDs should, if possible be marked with the patients birth number and a 4-digit control number and an "S" for Sweden if patients do not object. However, in reality, identification of cases with RPDs is usually managed using the information provided by remaining natural teeth. The marking could of course be useful when RPDs are mixed-up, misplaced or lost in institutions.

Another limiting factor to denture marking that has to be considered is the patient's opinion. The patients in this study had clearly not been systematically offered denture marking (65% of the dentists did not do it) while it occurred in only six cases and 14% of the dentists sometimes offered it. This is interesting since it appears that the dentists do not consider the patients' opinions regarding this matter. This is even more surprising since it is clearly stated in the recommendation that the patients should be asked about denture marking. We believe that

if the patients are properly informed about the purpose of the marking they will not object to the procedure. This is illustrated by the fact that only nine dentists in this study had experienced a patient who did not accept the marking while 63 dentists had not experienced any refusal from the patients. This is supported by Johanson and Ekman[3] who had not experienced any refusal to a denture marking and also accords with the findings of Cunningham and Hoad-Reddick[12] who found that the majority of the nursing home patients questioned in their study responded positively to the suggestion of identification marks on their dentures. On the other hand one reason why the dentists in this study experienced few refusals could be that they simply did not ask the patients.

Patient refusals were reported by the dentists for the following reasons: no wish to be identified as a denture wearer (n=1), not aesthetic (n=5) and resistance to registration (n-7). Since this study has demonstrated that some patients do not accept marking of their dentures an alternative method of denture identification should be considered. Other methods of marking could include the use of a smaller metal label or a pink (denture coloured) piece of paper/cloth,[17,18] a reduced format metal label in another not-so-visible area of the denture[19,20] which could be motivated by the fact that it is important not to weaken the material of the denture or burying a metal strip within the acrylic denture base during processing.[18] These efforts at hiding the mark are not considered justified however since the results from this study have shown that there were very few refusals.

Some dentists thought that it was not necessary on each occasion to ask the laboratory to mark the dentures as there may have been a standing arrangement with the dental technician to mark all dentures. This could be relevant as the number of dentures that are routinely marked by the dental technicians is higher than the number of requests from the dentists. Also, this study supports the fact that some dentists seem to mark "all dentures" while other dentists mark only a few. Olsson[13] and Johanson[14] found that all dentures that were made in the dental schools were marked but they also found that marking of dentures was rarely done in both private dental care (8%) and public dental care (18%). The results from this study however do not support earlier data stating that there was a difference between private and community dental care and besides, it was beyond the scope of this investigation to study differences between private and community dental care.

Most of the patients in this survey were satisfied with their dentures. This indicates that they would not visit a dentist who could recommend the marking of their dentures during the next few years and it is our opinion that even if the number of denture wearers decreases the problem of unmarked dentures will persist for many years to come.

Some of the results from this study should be interpreted with caution since 60 dentists did not answer the question regarding the reasons for marking the dentures or not. Unfortunately, only 16 of the dentists answered the question regarding the patients reasons for not accepting marking and this information would be valuable when the NBHW are re-evaluating the recommendations regarding denture marking.

We believe however, that if patients are properly informed about denture marking, the number of refusals would decrease.

Importance of denture marking

National surveys on the prevalence of edentulousness in selected age groups during 1970-1990 in the Scandinavian countries compiled by Ainamo and Österberg[15] indicate that it will be an oral status issue well into the future. The data for Norway and Sweden were similar, namely about 50% edentulousness in the seventies and a reduction to about 29% in the 1990s for the age group 65+. There was a smaller difference in edentulousness for the corresponding Finnish population between the 1970s (54%) and the 1990s (46%) but it should be noted that the latter figure represents the ages 65-80. Nevertheless, even if there were only a few denture wearers in Sweden it would be important to remember "given that only one marked denture can tell us the identity of a deceased when all other methods fail to do so makes it worthwhile to mark dentures".[16] In addition, the marking of dentures will also prevent them from being lost or inadvertently intermingled in institutions.

The explanation for the discrepancy in frequencies between our results of denture marking by dental laboratories in Sweden and results from previous studies[5] cannot easily be explained but one possible reason could be that the patients in hospital dental care have old dentures whereas the patients in our study had newer dentures. The legal and social implications of denture marking are therefore obvious. Furthermore, it is our opinion that this study was timely and important because the Swedish ID-band has become the international standard and Federation Dentaire International-accepted denture marking system.

Since most of the patients in this study were satisfied with their dentures they will probably not visit a dentist who could recommend denture marking during the next few years and the problem with unmarked dentures might well persist for some years to come even if the number of denture wearers decreases.

CONCLUSIONS AND FUTURE PERSPECTIVES

1. In this study the overall attitude among the dentists and patients was positive towards identification marking of dentures. We are therefore confident that there will be no obstacle to confirming the existing regulations.

2. The results from this investigation indicate that the dentists are to blame for the non-marking of dentures.

3. Previous studies have shown that denture marking can be crucial in the identification of deceased persons. Clinical experience shows that denture marking is important especially among hospitalised patients and that the recommendations of the NBHW should be stressed by the proper authority.

4. Most of the patients in the present study were satisfied with their dentures which indicates that they would not have any marking of their dentures during the next few years. It is our opinion therefore that the problem of unmarked dentures will persist into the future.

5. Even though the patients in this study would prefer dental implants to dentures, today's economics would not allow for such expensive treatment and the number of dentures will probably not decrease during the years to come.

6. International collaboration should be increased and different opinions among the world-wide community of forensic odontologists discussed with the aim of reaching some kind of consensus in the future. In the legal establishment as well as in society ethical principles must be upheld since the socio-economics of denture marking differ from one country to another. We suggest therefore that dental societies and similar bodies should make a serious effort to bring the issue to the notice of governments and populations so that the implementation of the programme is accelerated.

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APPENDIX 1

Questionnaire to dentists

The questions to the dentists were:

1. For how long have you been working as a dentist ?
   - Less than a year
   - 1-5 years
   - 5-10 years
   - 10-15 years

2. How many full dentures do you make per year?
   - 1/year
   - 1-5/year
   - 5-10/year
   - more than 10/year

3. How would you estimate the amount of full dentures made by you in your practice which are marked with the patients personal number ?
   _____%

4. How would you estimate the amount of full dentures that you came in contact with in your practice which are not marked with the patients personal number ?
   _____%

5. Does it happen that you, in spite of your request, get unmarked dentures from the dental technician ?
   - Yes
   - No
   - Don't know

   If the answer is "yes" what is your reaction ?
   _____
   _____

6. What percentage of dentures do you request your technician to mark ?
   _____%

7. Do you ask for the patient s permission before you order marking of the dentures ?
   - Yes, always
   - Yes, sometimes
   - No

8. Which are the reasons for you not to mark the dentures with the patient s personal number ?
   _____
   _____

9. Does it happen that patients don t want their dentures to be marked ?
   - Yes
   - No

Questionnaire to patients

The questions to those patients who were wearing some kind of prosthesis were:

1. When did you get your first denture ?
   - Less than 5 years ago
   - 5-10 years ago
   - More than 5 years ago

2. When did you get the denture you are wearing now ?
   - Less than 5 years ago
   - 5-10 years ago
   - More than 10 years ago

3. Is the denture that you are wearing now marked ?
   - Yes
   - No
   - Don't know

4. Did the dentist ask for your permission to mark your denture ?
   - Yes
   - No
   - Don't know

5. Are you satisfied with the denture that you are wearing now ?
   - Yes
   - No

The questions to those patients who were not wearing some kind of prosthesis were:

1. If you were to get a denture in future, would you permit it to be marked with your personal number ?
   - Yes
   - No
   - Don't know

   If the answer is "yes" or "no", please explain why:
   _____
   _____

2. Which treatment would you prefer if you were asked to choose between dental implants (fixed teeth) or an ordinary denture (not fixed) ?
   _____

3. How is your present dental status ?
   - Very bad
   - Bad
   - Insufficient
   - Sufficient
   - Good
   - Splendid

4. Do you lack any teeth?
   - Yes
   - No

   If yes, how many?
   _____

DENTAL IDENTIFICATION OF DECOMPOSED VICTIMS IN A CASE OF MULTIPLE HOMICIDE BY INJECTION OF SUCCINYLCHOLINE

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ABSTRACT

A bizarre criminal case of suspected multiple homicide by poisoning with an anaesthetic drug (succinylcholine) is reported. Five victims were found buried in a rural area, two female victims (ca. three months after death) had undergone moderate decomposition and three males (ca. one-and-a-half years after death) showed advanced post-mortem changes, adipocere formation and skeletonisation. The identities of two female and two male victims (21-47 years old) were immediately established by comparisons between ante-mortem and post-mortem intra-oral radiographs and/or orthopantomographs. The other male could not be definitely identified because of lack of ante-mortem radiographs, but multiple dental and circumstantial evidence supported the identity. Their blood groups and DNA profiles also supported the identities but it is concluded that recent advances in DNA technology do not reduce the merits of dental identification. **(J Forensic Odontostomatol 1997; 15: 37-44)**

Keywords: Forensic odontology, multiple homicide, dental identification, radiography

INTRODUCTION

Identification of multiple victims in mass disasters and multiple homicide is one of the more onerous tasks facing forensic odontologists.[1-29] In cases of serial homicide and concealment, the victims' bodies are often recovered months or years after death[2-4] and advanced post-mortem changes complicate identifications. On the other hand, prompt establishment of their identities is required for effective crime investigation and for relatives' peace of mind. In such cases, dental examination at the scene or in the mortuary may play an important role even prior to the autopsy itself.[28]

We report an unusual criminal case of suspected multiple homicide by poisoning with an anaesthetic drug (succinylcholine) and concealment, in which dental examination greatly contributed to establishment of the victims' identities.

CASE HISTORY

In the autumn of 1993 in the city of Osaka, Japan, it was established that two female and three male missing persons and a dog breeder had been involved with one another in some serious financial problems. Three males had already been missing about one year before and in January-February, 1994, following a suspect's confession, the bodies of all the victims were found buried in a rural area some distance from Osaka. The suspect confessed that he had injected succinylcholine (a muscle relaxant) intramuscularly into the victims after sedation by oral administration of a small amount of hypnotics (bromisovalum and/or nitrazepam) contained in drinks. As a dog breeder he had experience of killing dogs by this method and the drugs were illegally provided by a veterinary surgeon of his acquaintance once again under the pretence of killing unwanted animals. As can be expected this case attracted widespread interest and publicity following this unusual form of murder and also because of the number of victims involved.

The bodies of two female victims (ca. three months after death) had undergone moderate decomposition. Three male victims (ca. one-and-a-half-years after death) showed advanced post-mortem changes: adipocere formation and skeletonisation. Autopsy revealed a puncture site in the upper arm of a victim and pulmonary oedema with pleural effusion common to two relatively intact victims which strongly suggested advanced respiratory distress as the immediate cause of death by injection of a muscle relaxant. Succinylcholine could not be detected in the bodies but was still identifiable in a syringe found near the corpses. Small amounts of bromisovalum and/or its metabolite were detected in two bodies and these pathological and toxicological findings supported the circumstantial evidence of the mode of death as subsequently confessed by the suspect and this was therefore the presumed manner of killing.

The personal files including dental records of possible victims had been completed before recovery of the bodies. The remains were identified in accordance with their physical and dental characteristics, as well as blood groups and DNA profiles (data provided from Forensic Science Laboratory, Osaka Prefectural Police Headquarters), as shown in Table 1. DNA analysis for HLA-DQα and D1S80 typing from muscle tissue specimens was successful in supporting the identity of Victim B. The dental identifications were performed as described below and furthermore the blood groups supported the identities of all the victims.

DENTAL IDENTIFICATION

In the process of retrieving the victims, prompt identification was required to confirm that this crime was a serial homicide and to establish a basis for the possible involvement of any other unknown victims. Identification was therefore performed by forensic dentists in co-operation with a forensic pathologist on the scene as a preliminary procedure, in the mortuary and at autopsy.

Victim	Age(year) /Gender	Postmortem Radiograph	Antemortem Radiograph	Dental record	Dental identification evidence	Conclusion	Other evidence
A	47/F	10 IRS	OP	-	bridges crowns fillings partial dentures root canal fillings	positive	clothes personal effects blood group
B	47/F	2 IRs	1IR	+	fillings bridge screw post	positive	clothes personal effects blood gorup DNA profile
C	24/M	10 IRs	5IRs	+	bridge fillings impacted teeth	positive	blood group
D	34/M	10 IRs	-	+	restoration	compatible	personal effects blood group
E	21/M	10 IRs	1IR	+	bridge root canal fillings	positive	blood group

F, female; M, male; OP, orthopantomograph; IR, intraoral radiograph; +, available; -, not available
Morphological dental features in radiographs were useful for positive interpretation in all cases examined.

Table 1: Identification evidence of the victims.

The first body found was that of a middle-aged female victim (Victim A). Two possible female victims were of the same age and also of similar physical characteristics. Fortunately, the clothes on the body of Victim A were still relatively well preserved and these together with personal effects were useful for preliminary identification. Post-mortem examination by inspection at the scene revealed dental evidence of bridges, metal crowns, fillings and maxillary and mandibular partial dentures and she was identified in comparison with the ante-mortem dental information of a possible victim (47 years-old). Subsequent radiographic comparisons with the ante-mortem dental x-ray film revealed additional evidence of root canal therapy and morphological features of the roots to confirm the identity (Fig.1).

About two weeks later, another female (Victim B) was found. Once again, well preserved clothes and personal effects were useful for preliminary identification but dental examination was not possible at the scene because the head was totally covered with a plastic bag and tightly bound with adhesive tapes, and it was obvious that very careful pathological examination was required. The body was immediately sent to our Institute and at autopsy was identified as the other possible female victim (47 years-old) based on dental evidence including fillings and a bridge. Subsequent radiographic comparisons with the ante-mortem dental x-ray film disclosed additional evidence of a screw post to establish positive identification (Fig.2).

Three male victims (Victims C, D and E) were then found. Two of whom (C and E) were of similar youthful age and the third (D) was somewhat older. Advanced decomposition of the bodies complicated anatomical identification. Victim C could not be positively identified by inspection owing to the lack of dental records. In consideration of possible involvement of an unknown victim, post-mortem radiographic examination was immediately carried out by means of a portable apparatus in the mortuary of a police station. The comparison with the ante-mortem films of a possible victim (24 years-old) established the identity. Evidence of multiple dental fillings, location and morphological features of roots and impacted teeth was useful for positive identification (Fig.3). A dental bridge found in the victim was not observed in the ante-mortem radiographs but had been written in the dental records after the x-ray examination. In the youngest victim (E, 21 years-old), evidence of aesthetic dental treatment (a bridge) was useful for positive identification by inspection.

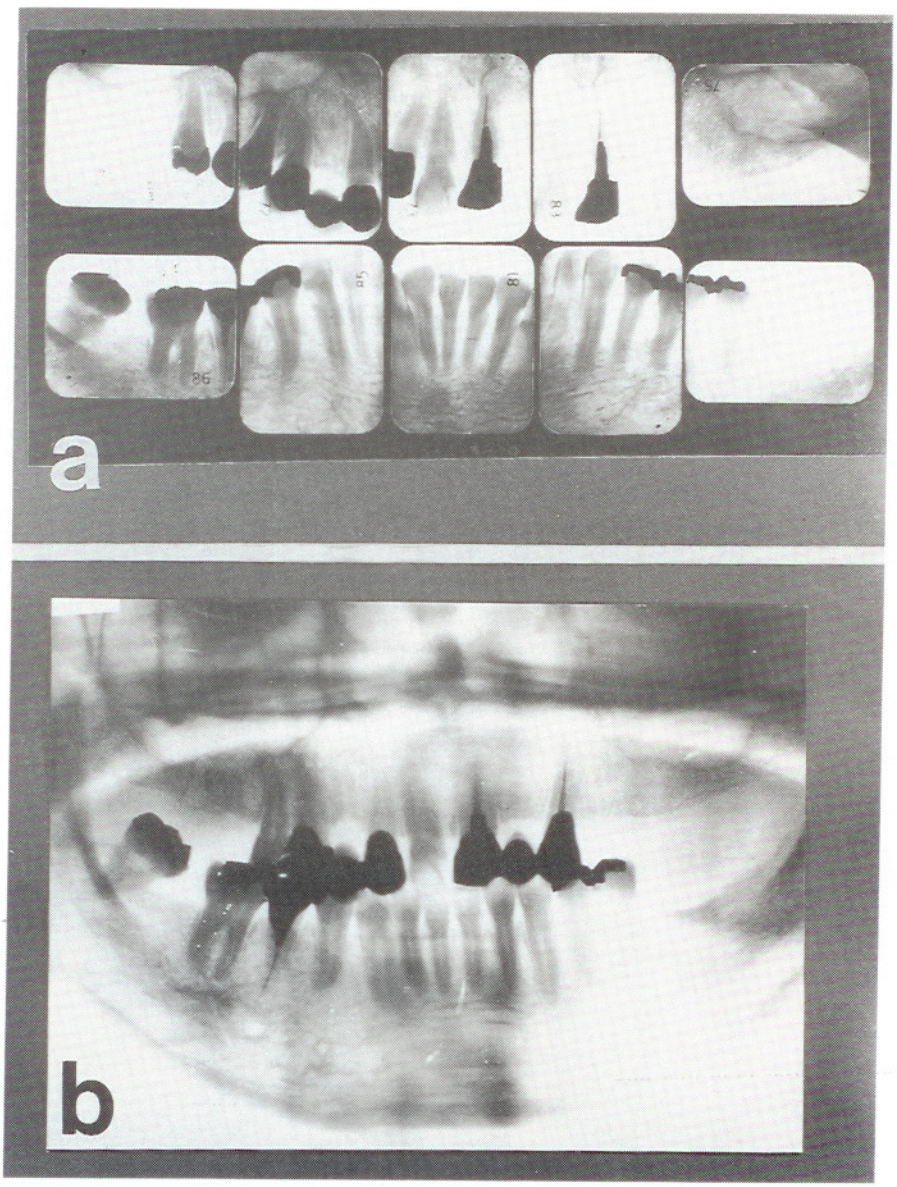

Figure 1: Radiographic comparison of (a) postmortem intro-oral dental radiographs of Victim A with (b) the antemortem dental orthopantomograph.

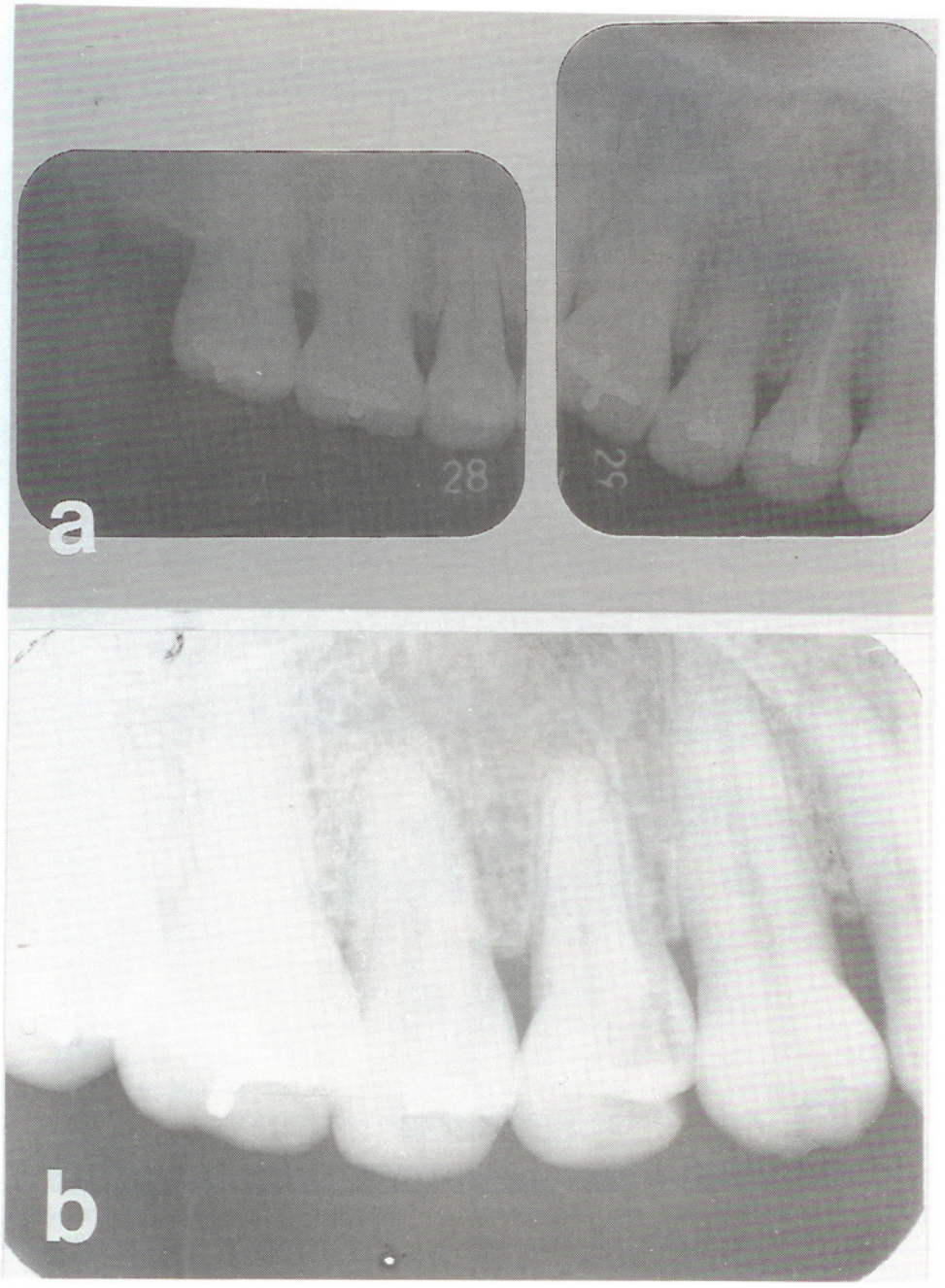

Figure 2: Radiographic comparison of (a) postmortem intra-oral dental radiographs of Victim B (upper right molars, premolars and canine) with (b) the antemortem radiographs (upper right first and second molars, premolars and canine).

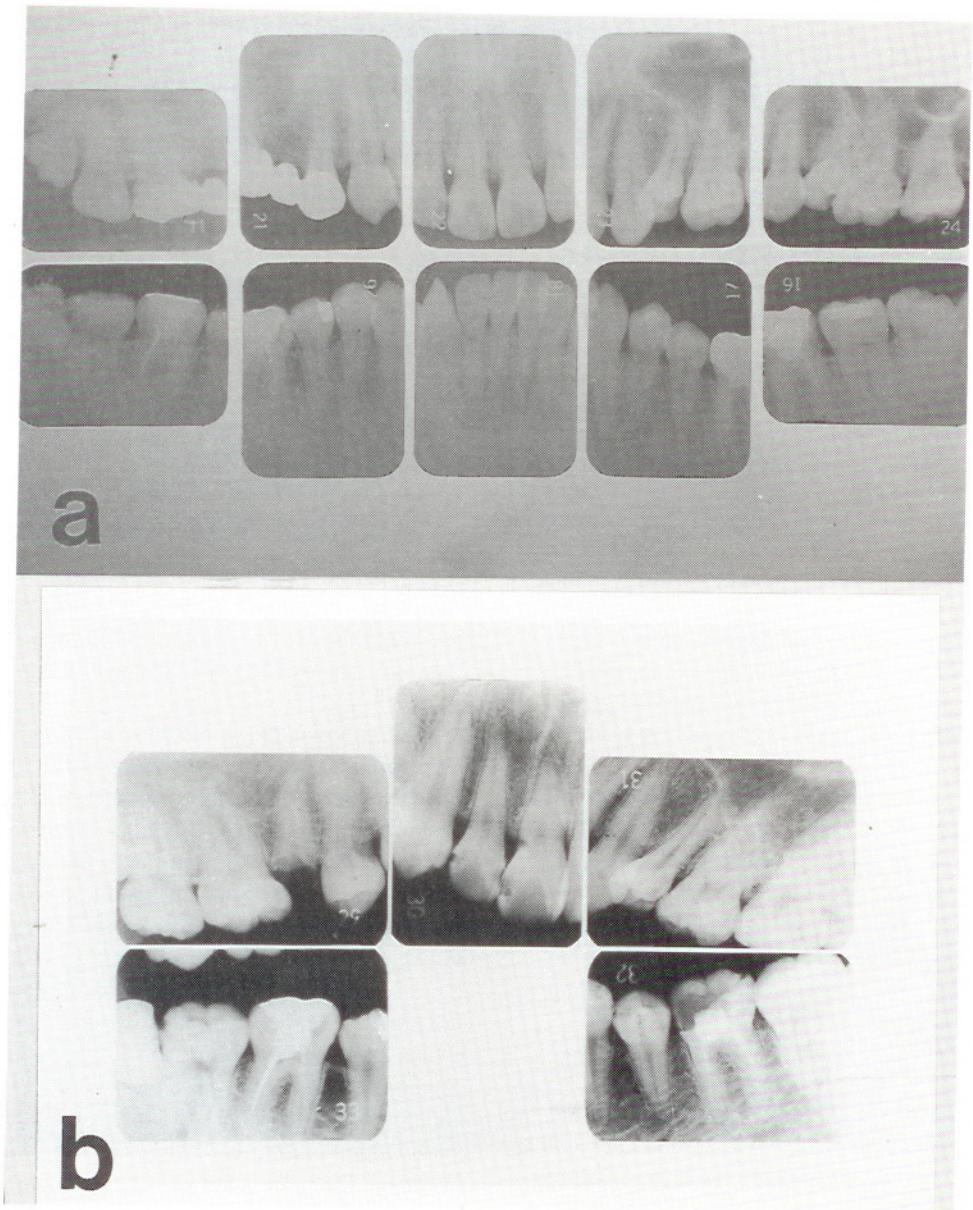

Figure 3: Radiographic comparison of (a) postmortem intro-oral dental radiographs of Victim C with (b) the antemortem ones.

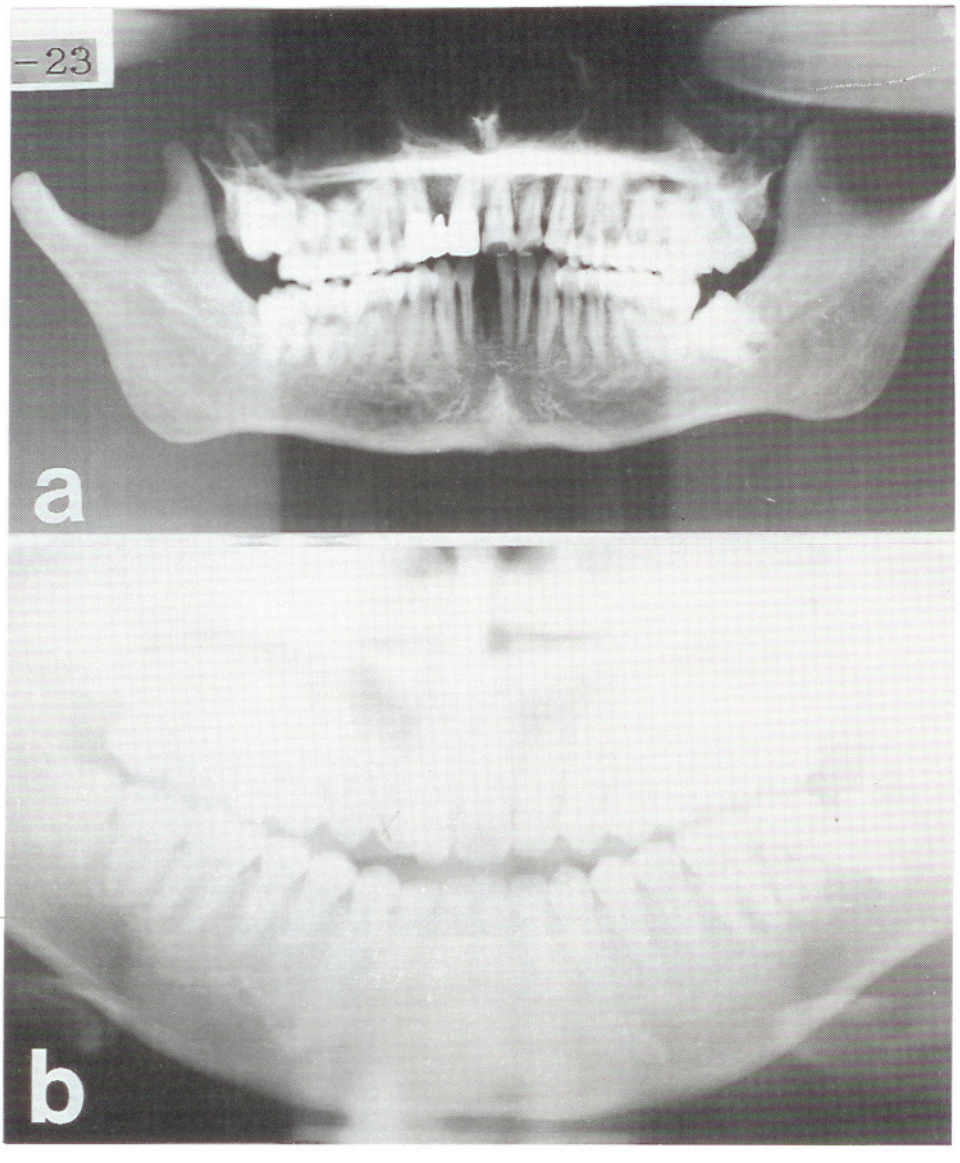

Figure 4: Radiographic comparison of (a) postmortem dental orthopantomograph of Victim E with (b) the antemortem one.

The upper and lower jaws of the three male victims were resected at autopsy and examined further, since other identification evidence was very poor due to advanced post-mortem changes.[7,22-28] It was useful also to obtain a dental orthopantomograph for comparison with the ante-mortem film of Victim E (Fig.4), in which evidence of root canal therapy and morphological dental features confirmed the identity.

For the oldest male (D, 34 years-old) ante-mortem radiographs were not available but observation of dental restorations, which was confirmed by further examination of the resected jaws, coincided with the ante-mortem dental records. Circumstantial evidence including personal effects also supported the identity.

DISCUSSION

Homicidal poisoning with muscle relaxants is a very unusual form of assault.[30-33] It is almost impossible to identify succinylcholine in autopsy material since the drug disappears promptly from the circulating blood owing to redistribution and hydrolysis by plasma cholinesterase and liver esterases,[34] and this was a finding in the case reported above where succinylcholine could not be identified in the victims. However, the pathological and circumstantial evidence supported the manner of assault as confessed by the suspect and the cause of death was presumed to be poisoning with succinylcholine.

Serial homicide is not a common experience for forensic pathologists and dentists. In the retrieval of remains of multiple victims identification is a matter of urgency for the police and relatives. Dental identification plays a very important role especially when the bodies are badly decomposed or damaged and the successful application of odontological examination and identification has been previously reported.[1-4] The "Green River Murders" reported by Haglund *et al.*[2] appears to be a unique case especially concerning the number of victims. The authors reported that the major sources of difficulty in the victim identification process were: (1) delay in discovery of bodies, (2) recovery and condition of the remains (e.g. skeletal disarticulation and bone scattering), (3) age of the victims (youth), (4) unstructured lifestyle of the victims, (5) their status as "missing persons" and (6) retrieval of ante-mortem dental and hospital records which increased the elapsed time from discovery to identification in many instances.

In our case, the personal files including dental records of possible victims were already completed before recovery of the bodies. Prompt establishment of the victims' identities was an essential legal requirement, and also necessary in consideration of possible involvement of any other unknown victims. In this case, the police actually requested dental identification at the site of recovery and we made a determined effort to meet the request, but took every precaution to avoid possible contamination or damage to the bodies. Serial identification was then performed throughout in co-operation with a forensic pathologist and forensic dentists,[26] based on the anatomical and dental characteristics. Advanced post-mortem changes and similarity of the ages and physical characteristics confused anatomical identification but preliminary post-mortem dental examination of Victim A by inspection at the site of recovery showed multiple dental evidence and allowed probable establishment of the identity.

Dental examination including radiography by means of a portable apparatus was applied to Victim C whose face was almost skeletonized, in the mortuary prior to autopsy. It was applied to the other victims immediately after autopsy in order to avoid damage to the face before pathological investigation. Four of five victims (A, B, C and E) were positively identified by comparison between ante-mortem and post-mortem radiographs while the other male victim (D) could not be reliably identified because of lack of ante-mortem radiographs. Multiple dental and circumstantial evidence however supported the identity and ruled out the possible involvement of another unknown victim.

The blood groups and DNA profiles subsequently also supported the identities. DNA profiling (HLA-DQα and D1S80) was useful for one victim out of five. Recent advances in DNA analysis have greatly improved the accuracy of polymorphism identification while STR (short tandem repeat) systems may be more promising in the identification of badly decomposed remains. These recent advances in DNA technology however do not reduce the merits of dental identification which remains a simple, effective and rapid technique in establishing identity.

In conclusion, dental identification proved to be very useful in this case, providing important, positive evidence for prompt establishment of the victims' identities as well as exclusion of possible involvement of other unknown victims. On-site and in-the-mortuary identifications yielded valuable preliminary information which allowed a significant speeding up of the procedure.

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