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CONTENTS

INDIVIDUALISATION OF DENTAL TISSUE - AN AID FOR ODONTOLOGICAL IDENTIFICATION?*

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ABSTRACT

The introduction of new methods in forensic diagnostics, especially serological techniques, including the use of individual markers for identification is becoming increasingly important. The DNA techniques are particularly promising and dental tissue, especially dental pulp, is a good source of DNA because it is well protected against autolysis. Gc-subtyping and application of DNA techniques for identification were reported in 1992 and show the efficacy of PCR systems for the individualisation of dental tissues. In cases of optimal conditions - room temperature and dry air - the analysis was successful after 6 or 12 months and the results could be used for identification. Under the influence of high temperature autolysis occurs and the pulp degrades making DNA typing almost impossible. The experiments show that the system HLA-DQ_α is more reliable than the system MCT 118 and the results confirm that these techniques can be used for identification of unknown persons in some cases. The methods are only usable if comparative material belonging to the subject, such as hair, is available. **(J Forensic Odontostomatol 1995; 13:1, 1-3)**

Keywords: Identification, forensic odontology, serological techniques, DNA-typing, dental pulp

INTRODUCTION

Forensic odontological examination is one of the most efficient methods for the identification of unknown persons, but not always. In reality there are mass disasters in which extensive mutilation of victims takes place so that routine identification is impossible. Computerisation of dental records has gone a long way to assisting the process but experience shows that identification using computer software can be problematic too, and may not provide the desired certainty, particularly when comparative records are inadequate. The increasing use of diagnostic methods such as panoral radiographs in general practice however provide enhanced possibilities for identification but again, not all patients are radiographed in this way.

As the dental tissues in burned bodies are well protected, the pulp is a suitable material for identification by methods such as ABO blood typing, Gc-subtyping and for gender determination. Furthermore newer technologies, especially at molecular level such as the use of genetic markers,[1] have pushed the frontiers of identification back even further. These DNA techniques promise to solve many problems particularly as dental pulp is a good source of DNA because it is well protected against autolysis.

Gc-subtyping and the application of DNA techniques for identification have been reported[2,3] and in this paper the results of individualisation with southern blot analysis using single locua VNTR (variable number of tandem repeat) probe pYNH24 (locus D2S44) has created the possibility of testing with PCR (polymerase chain reaction) typing.

MATERIAL AND METHODS

Dental pulp tissue was obtained from routine clinical dental extractions and from forensic casework as follows:

1. extractions during dental treatment and stored at room temperature for 12 months,
2. extractions post-mortem and stored at room temperature up to 6 months after death,
3. teeth from 2 murder victims who were found after one week in a forest partly covered with earth at a depth of 10-20cm where a temperature of about 50°C was measured,
4. teeth from a victim of an accident who died after fire.

The PCR typing was done in the HLA-DQ_α and D1S80 (MCT 118) systems. After opening the pulp cavity and extirpation of pulp tissue DNA was extracted by chelex.[4] The amplification was carried out with the following primer sequences and conditions:

D1S80 (MCT118)[5]

5'- GAA ACT GGC CTC CAA ACA CTGH CCC GCCG - 3'

5'- GTC TTG TTG GAG ATG CAC GTG CCC CTT GC - 3'

temperature: 94/65/72°C

time: 60/60/60 sec

cycles: 30

The PCR products were separated by electrophoresis in a polyacrylamide gel and visualised by silver staining.

The conditions for electrophoresis:

Power Supply

1. 4 W, 40mA, 1000V, 90'
2. 8 W, 40mA, 1000V, 90'
3. 10 W, 50mA, 1000V, 90'

Gel: PAA 0, 5mm, T 4,5%, C3%

Electrodestrips: 2% Agaroseplaques/Tris-Borat-Buffer

Temperature: 8°C

HLA-DQ_α [6]

5'- GTG CTG CAG GTG TAA ACT TGT ACC AG - 3'

5'- CAC GGA TCC GGT AGC AGC GGT AGA GTT G - 3'

Amplification and allele analysis were carried out using the Amplitype HLA-DQ_α (Forensic DNA Amplification and Typing Kit).* & Reaction mix: HLA-DQ sequence specific biotinylated primers, AmpliTaq DNA polymerase, dATP, dGTC, and dTTP in buffer.

temperature: 94/60/72°C

time: 60/30/30 sec

cycles: 31

This technique uses a reversed dot blot method, in which the amplified DNA is labelled during PCR by incorporation of biotinylated primers. The allele specific oligonucleotide probes are immobilised side-by-side on a probe strip.[7]

RESULTS

The experiments revealed that the dental pulp can be a reliable source of DNA for PCR-analysis in the systems HLA-DQ_α and MCT 118. The efficiency of the DNA-typing depends on the conditions of storage of the teeth. For example, the teeth extracted during dental treatment and stored for 12 months at room temperature yielded 100% successful identification

* *Cetus Corporation, Emmeryville Ca, USA.*

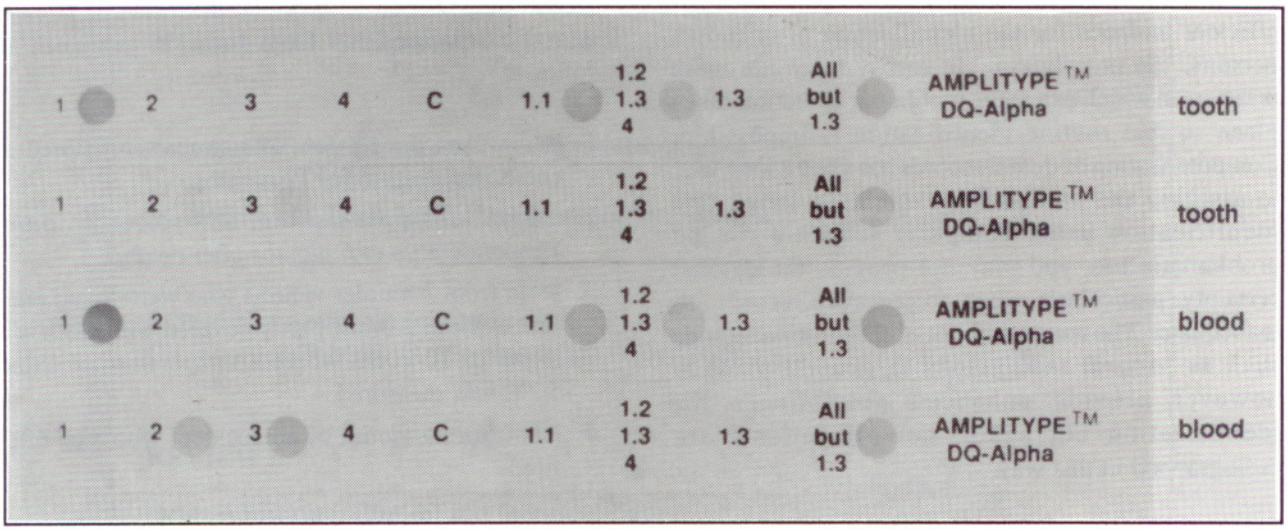

Fig 1 PCR-Analysis in system DQ-alpha. Extracted teeth and blood from the same patient for comparison.

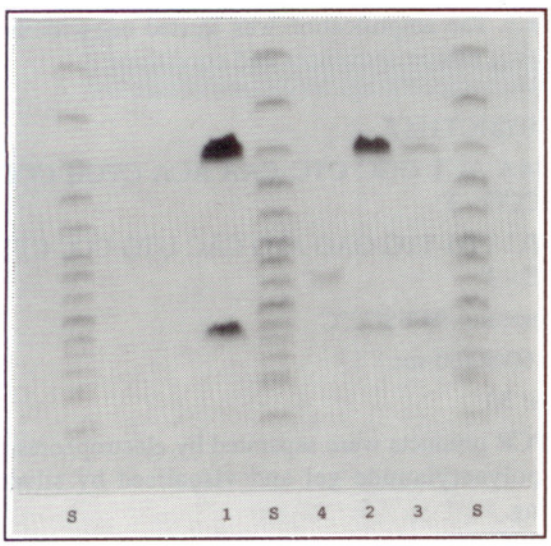

Fig 2 PCR-Analysis in system D1S80. S - standard allelic ladder, 1 - blood from the same patient (for comparison), 2 - extracted tooth (molar) stored 8 weeks, 3 - extracted tooth (molar) stored 3 months and 4 - control (known alleles).

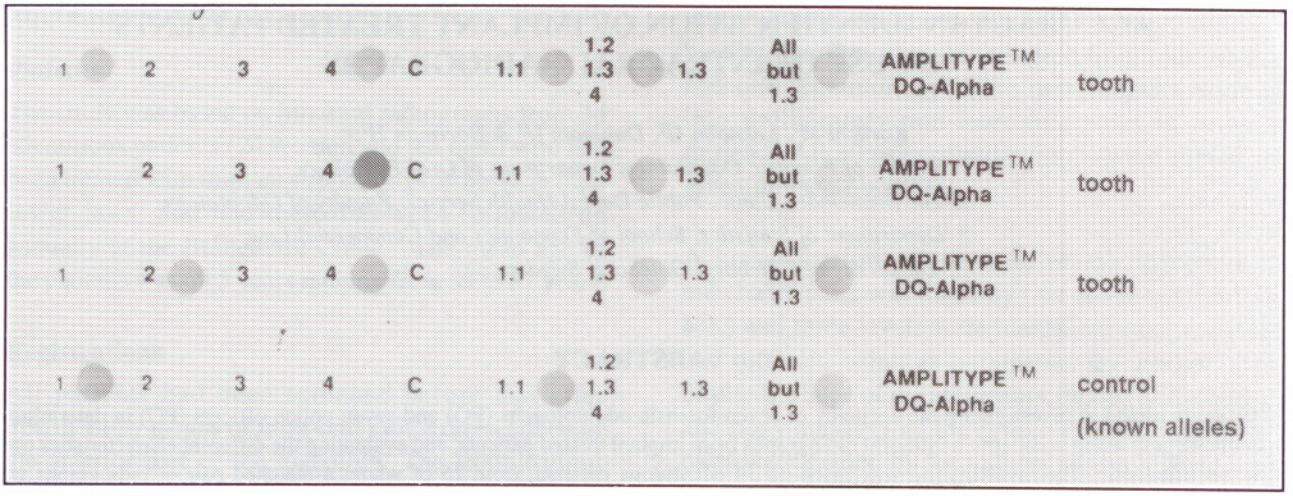

Fig 3 PCR-Analysis in system DQ-alpha. Postmortem extracted teeth stored 8 weeks.

(Figs.1 and 2).

The teeth extracted post-mortem and stored for 6 months at room temperature were always identifiable using the HLA-DQ_α system, but only in some cases using MCT 118 (Fig.3), because it needs longer fragments of DNA than the HLA-DQ_α. The degradation of the dental pulp tissue on the other hand in any case prevents effective typing with MCT 118 in these cases.

The teeth from the victims of murder, with their autolytic pulps, could not be used for DNA-typing because the tissue was decomposed and had lost all traces of DNA. The same results were obtained in the cases of death after fire where all DNA was destroyed by the high temperature and the PCR did not yield any positive results.

DISCUSSION

In cases of a normal environment the dental pulp remains well protected in the pulp cavity and DNA can be obtained successfully, which is particularly important as a high quality DNA is necessary for identification by PCR. The PCR typing from dental pulp tissue was in agreement with the results obtained from blood stains or other tissue.

Following fire and putrefaction however the tissues gave uncertain results. In these cases the quality of DNA was not sufficient for typing as, in addition, bacterial contamination and autolytical processes could be troublesome. In such cases DNA is often decomposed into very small pieces and only a new generation of PCR-VNTR-system, the so called STR (short tandem repeat) system, will work. Because of their small allele sizes (<300bp) they are more likely to be successful on old specimens that contain only degraded DNA. These techniques were not part of this study, however, but will be applied in the future.

PCR-based techniques may be important in cases of identification of unknown persons where identity cannot be determined by personal items or dental means. The method of DNA analysis is a comparative one and requires the existence of a known DNA sample belonging to the subject, such as hair, results of paternity testing or living relatives, which is analogous to an ante-mortem dental record being compared to the post-mortem record. DNA analysis is an extremely valuable tool in the identification armamentarium but the material does deteriorate in certain circumstances.

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ACCURACY IN IDENTIFICATION OF IMPLANT TREATED PATIENTS BY USE OF INTRAORAL RADIOGRAPHS

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ABSTRACT

This study aimed at investigating the accuracy of seven forensic odontologists (FO) and seven police officers (PO) in determining person identity using comparable intraoral radiographs from implant treated patients, and evaluating the different characteristics used for identification. The investigation was based on 34 edentulous patients, from 26 of whom a matched pair of radiographs was constructed in such a way that one, taken after insertion of an implant supported prosthesis in the anterior part of the mandible, was regarded as the antemortem radiograph, while another picture from a later follow-up examination served as the postmortem x-ray. From each of the remaining eight patients similar radiographs were selected so that four antemortem and four postmortem ones were obtained. These eight radiographs were also paired but did not match. There were thus 30 pairs of radiographs. A classification of the 26 matched pairs regarding degree of ease (easy, moderate, difficult) in combining the radiographs, using as parameters the design of the implants, shape of the abutments, shape of the bridges and bony anatomy of the jaws was established. The total number of errors made by the FO were higher (26) than those made by the PO (18) (one PO combined all 26 matching radiographs correctly) and 12 of the 26 matchable cases were correctly paired by all observers. The design of the fixed prostheses was the most often used characteristic in the exercise. **(J Forensic Odontostomatol 1995 13:1 4-8)**

Keywords: Dental implants, person identity, radiographs, police officers, forensic odontologists

INTRODUCTION

The use of radiography as a tool for person identification in mass disasters and individual deaths has been strongly recommended because of its accuracy.[1,2] The legal aspects of using radiographs have also been described.[3] In previous reports[4,5] the ability of different dental specialists to identify individuals by means of intraoral radiographs has been tested, the results showing that the evaluations of radiologists were superior to those of other specialists. In another study the accuracy in determining identity by dentists knowledgeable in forensic odontology[6] by means of intraoral radiographs was investigated. In it 17 odontologists examined radiographs twice and the two colleagues who made the most errors on 31 pairs of x-rays available for evaluation in the first examination made 11 and 13 errors each. The results from the report indicated that it was an advantage to have a forensic odontologist, trained and experienced in oral radiology, when doing dental identifications via radiographs.

In a similar study[7] on the accuracy of 11 police officers to establish identity by means of 31 pairs of intraoral radiographs, a relatively large variation in the judgements between the observers was found. The minimum number of errors made by the police officers was about the same as the maximum number of errors made by the dentists. The outcome of the study indicated that the final decision about identity should be made by more than one person. This has previously also been suggested by others,[8] especially for mass disaster situations. However, in the abovementioned report,[6] the observers formed their own criteria for the evaluations. Furthermore, they were not instructed to describe the characteristics they used for identification.

Since oral implant therapy has become popular worldwide, it must be of interest to perform an identity study of persons with implants. In Sweden, the most commonly used implant technique is the procedure *ad modum* Brånemark,[9] clinically used since 1965 and in which patients with oral implants are followed up postoperatively by clinical and radiographic examinations.[10] The total material of the Brånemark Clinic in Göteborg, Sweden, currently amounts to more than 20,000 fixtures, inserted into jaws of some 4,000 patients. Worldwide, there are about 300,000 individuals who have gone through this treatment, with the number rapidly increasing. Consequently the possibility of finding an oral implant patient treated according to the Brånemark technique in an identification situation is increasing.

The aim of the current study has been to investigate the accuracy among forensic odontologists and police officers from the homicide department in determining person identity using comparable intraoral radiographs from implant patients, and to identify the different characteristics which are used for the identification.

MATERIAL AND METHODS

Patients

The study was based on intraoral radiographs from 34 edentulous patients (24 women and ten men) who had been treated with implant supported prostheses in their lower jaws[9] and had thereafter been followed up annually at the Brånemark Clinic. The mean age of the patients was 69.5 years ranging from 39 to 87 years.

Registrations

All patients had been screened before and after treatment by means of intra-oral radiographs covering the anterior part of the mandible. The examinations had been performed at the Department of Radiology, Faculty of Odontology, Göteborg, Sweden, in accordance with a technique by Hollender and Rockler.[10] The films used were Kodak Ultraspeed*, 3 x 4 cm in size. The radiographs were obtained using parallelling technique with varying dental x-ray machines, exposures of 60-70 kV, 12 mA and a focus-skin distance of 25 cm.

A matched pair of radiographs representing an "antemortem" and a "postmortem" record was compiled for each of 26 patients. The "antemortem" film was taken directly after insertion of the implant bridge while one from a later follow-up examination served as the postmortem picture (Fig.1).

The time interval between the "antemortem" and "postmortem" radiographs varied with a range from one to three years. The "antemortem" radiographs were coded with numbers and the "postmortem" ones with letters.

From each of the remaining eight patients only one "antemortem" picture was selected from four subjects and one "postmortem" from four subjects made up into deliberately non-matching pairs in order to mislead. All 30 pairs of radiographs were copied and given to each observer.

A classification of the ease-of-matching the 26 matchable pairs was made by two of the authors (HB, MK) and three levels were identified: easy, moderate and difficult, using as parameters the design of the implants, shape of the abutments, design of the bridges and bony anatomy of the jaws. The four unmatched pairs were graded by the authors as unmatchable, and it was expected that the observers would do the same. The outcome of the grading is shown in Table 1.

Table 1:
Distribution of authors' (n=2) and observers' (n=14) judgements regarding the degree of ease in matching the radiographs (n=30).

	Authors		Observers	
Degrees	no	%	no	%
Easy	36	60	168	40
Moderate	14	24	105	25
Difficult	2	3	76	18
Not judgeable	8	13	71	17
	60	**100%**	**420**	**100%**

**Eastman Kodak Co., Rochester, NY., USA.*

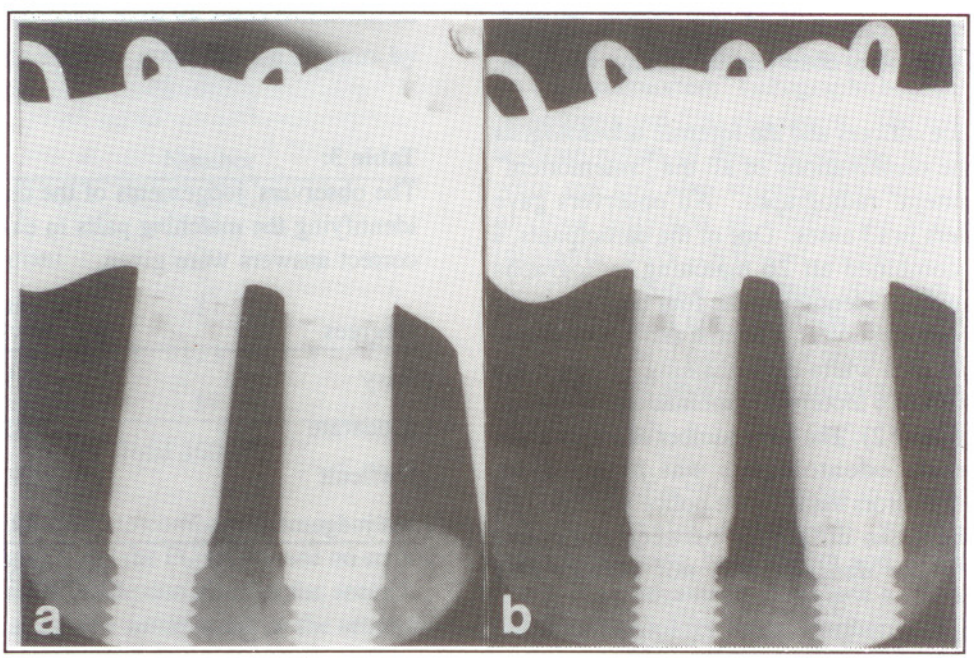

Fig 1a Intra-oral periapical radiograph showing the upper parts of two implants together with the abutments and parts of the superstructure. The radiograph was taken at the time of superstructure placement.
Fig 1b The same case as in a) after two years.

Observers

Fourteen observers were involved in the evaluations. They were briefed beforehand and informed in writing about the nature of the study. Seven of the examiners were police officers (PO) of 24-35 years standing, working in the homicide department of the Göteborg Police, with experience in forensics from between six and 25 years and had had specific duties in the homicide department for the last 6-25 years. The remaining seven observers had extensive clinical experience in dentistry (18-25 years) and had previously also participated in several continuing education courses in forensic odontology (FO). Their individual practical forensic experience ranged from 6-20 years.

The observers were informed that some of the 60 radiographs were unmatched. They were also asked to combine the matchable "antemortem" and "postmortem" radiographs into pairs and to leave the unmatchable ones without further consideration. Furthermore, they were asked to indicate, for each pair the degree of ease of combining the radiographs as well as to state which characteristics they used when doing so. Four police officers were asked to compare the cases when the superstructure was masked. This was done with the intention of testing whether the superstructure had any influence on the results.

Table 2:
Number of errors made in matching the radiographs by the 14 observers: police officers (PO) and forensic odontologists (FO).

Observer #	Profession	# of errors
1	PO	8
2	PO	0
3	PO	1
4	PO	3
5	PO	3
6	PO	1
7	PO	2
		Total 18
8	FO	1
9	FO	2
10	FO	5
11	FO	3
12	FO	6
13	FO	1
14	FO	8
		Total 26

RESULTS

The observers' (none of the authors) judgements of the degree of ease of matching the cases are shown in Table 1. Most of the pairs were considered to be easy and/or moderately easy to combine by the two authors (84%), but by the other observers the finding was 65%.

Both the police officers and the forensic odontologists completed the combinations of all the "antemortem" and "postmortem" radiographs. All observers gave correct answers in 13 cases. One of the participants, a policeman, combined all 26 matching radiographs correctly as well as identifying the four non-matching pairs. Two other observers, 1 dentist and 1 policeman, made 8 errors each while the remaining 11 observers ended up with 1 to 6 incorrect combinations of the test radiographs (Table 2). The total number of errors made by the forensic odontologists was higher (26), compared to the errors made by the police officers (18). However, the mean difference between the police officers and the dentists was not statistically significant.[11]

In the successful matchings (n = 376) it was found that most cases were judged by the observers as easy (165) or moderate (103), whereas only 59 cases were considered as difficult (Table 3). Of the 56 unmatchable cases 49 were detected by the observers.

Table 3:
The observers' judgements of the degree of ease in identifying the matching pairs in cases where correct answers were given.

Degrees	# observations
Easy	165
Moderate	103
Difficult	59
No judgement	49
	Total 376

Where the observers gave incorrect answers (n = 44) the degree of difficulty in identifying the cases is presented in Table 4. The incorrect answers were mostly found among those originally classified by the authors as "difficult" (17) while 8 observers gave incorrect answers on the cases which were judged to be difficult by all observers. The number of "easy" and "moderate" judgements were only 3 and 2 respectively and the number of unmatchable pairs was 22.

Table 4:
Observers' judgements of the degree of ease in identifying the matched pairs in the cases where incorrect answers were given.

Degrees	# observations
Easy	3
Moderate	2
Difficult	17
No judgement	22
	Total 44

The total number (n = 360) of main dental and anatomical characteristics used for the identifications made by 12 of the 14 observers is shown in Table 5. Specific details of the superstructures were the most commonly chosen characteristics for matching (123) and the shape of the abutment cylinders (81) as well as the design of the implant screws (70) were also frequently used. Bone anatomy structures (27) were seldom utilized and the number of unmatchable features was 59.

Table 5:
The characteristics used for matching the 30 pairs by 12 observers.

Characteristics	Number
Jaw bone anatomy	27
Design of the implant	70
Shape of the abutment	81
Configuration of the bridge	123
No specific characteristics	59
	Total 360

Four POs were now asked to compare the cases when the bridge was masked and the PO who made no error in the first evaluation, made one error in the second. Two observers made a few more errors in the second examination compared to the first one, while another observer made 10 errors in the second examination and only 1 error in the first.

DISCUSSION

In this study seven POs and seven FOs were asked to compare and match "antemortem" and "postmortem" radiographs of implant treated patients. The observers were informed that some of the pictures did not match and the study aimed thereby to illustrate an "open" identification situation in which the victims were not known or listed, such as may occur in a theatre or other public building accident, being in contrast to an airline disaster where a namelist of the passengers would be available. In an earlier study of the ability of forensic odontologists[6] to match radiographs of cases with different types of therapy, the observers were asked to evaluate the cases twice. Since the results from that study did not show any major differences between the two evaluations the observers in this study were only asked to evaluate once. An investigation with the current design is of course not realistic in the sense that the observers did not have the opportunity of using chart notes nor had any access to multiple radiographs. Furthermore, during practical work there is normally the possibility of collaborating with a colleague, when uncertain, and which was not permitted in this study. Instead, the aim was specifically to evaluate just one step in the combination and matching of the "ante-" and "postmortem" radiographs. This procedure has been done in previous research by our group.[4,5,6,7]

Interestingly, the total number of errors made by FOs and POs showed that the POs were more successful in matching the radiographs than the dentists. This phenomenon is difficult to explain and it could be that the policemen were more technically oriented in their ability to see through simulated forensic situations.

Another reason may be that the information on the "postmortem" images was too different from that seen on the "antemortem" radiographs because of different projections and film placement. The results from the re-examination of the radiographs when the bridges were masked also showed that the observers had obvious difficulty in identifying the pairs, if the implants only (without superstructure) were observable. Since the dental observers were neither oral radiologists nor specialists working with implant patients, i.e. oral surgeons or prosthodontists, they had obvious problems with the interpretation of the implant characteristics.

In earlier studies[4,5,6] differences in observation ability between dental specialists when evaluating radiographs have been shown and it was concluded that it is an advantage to include a radiologist in the forensic odontology team. Furthermore, quite a large variation between dentists who are knowledgeable in forensic odontology was also found.[6] An earlier statement about the importance of experience in

radiology for forensic odontologists is therefore confirmed.

In these studies[4,5,6] different types of identification cases were used in order to try to pinpoint the characteristics of a difficult case. In the current report it was decided to work only with radiographs in order to test one part of the identification procedures, i.e. the interpretation of radiographs. There is also a legal consideration in the use of x-rays as they constitute an accurate and permanent record which can be presented in court to prove or exclude an identity. This holds true especially for cases having an identical number of restorations, usually in the young. In these cases radiographs will best disclose the finer details of individuality. However, radiographic information alone must be interpreted with special care and in a real forensic situation it has been found to be essential to have several radiographs from the same area, and at different angles,[12] in order to display as many details as possible for comparison between the ante- and postmortem findings. When only one antemortem radiograph is available the forensic odontologist will take several postmortem radiographs to find a similar projection. Furthermore, the postmortem material can be distorted, as in cases of fire, and it is crucial to find comparable areas within the radiographic images. None of these possibilities however were given to the observers in the present study and the current research design can therefore be regarded more as a simulation of a fire accident with limited fragmented material.

The outcome of the current study has indicated that when identifying implant patients by means of radiographs there does not seem to be a need for any special knowledge or experience in dental radiography nor in the field of oral implant treatment. Justifying this statement is the fact that most of the observers used specific features of the superstructures as a basis for their identifications and police officers were better in this work than the forensic odontologists.

If the small number of easy cases which were correctly solved is compared with the number being incorrectly matched then the number of correct answers was significantly higher than the number of incorrect ones. This information is interesting because it indicates that the observers were aware of their own limitations, which is also in accordance with findings of the earlier study on accuracy among forensic odontologists.[6] In view of the present results we would like to emphasize the opinion presented by many forensic odontologists that forensic tasks should be performed by at least two collaborators experienced in forensic work i.e. one doing the examination and the second checking and taking notes.[8,13]

The conclusions from this study are that:

1) the observers found it more difficult to identify the different individuals using radiographs than the authors,
2) incorrect answers were mostly found among cases originally judged by the observers as difficult.

ACKNOWLEDGEMENT

We would like to thank the seven police officers and the seven Nordic forensic odontologists who participated in this study. Without their contribution the investigation would not have been possible.

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IN SEARCH OF A SUITABLE DENTURE MARKER

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ABSTRACT

The ID-Band (SDI AB, Sweden) has become the standard, internationally and FDI accepted denture marking system. In Australia however the strip is not easily obtainable and is expensive. Two other materials have been trialled as possible alternatives: (1) Titanium foil (9μm) and (2) Ho Band (matrix) (3μm) (Lorvic Corp, USA). All three bands were tested for tensile strength and elongation at temperatures: RT, 700° and 900°C. As the ID- and Ho Bands are both 18-8 stainless steel their performance was similar.

The 18-8 was stronger, had a higher percentage break point and a higher elongation. The latter meant that it was softer and could be more easily inscribed and was therefore more suitable for denture marking. Ti is becoming increasingly used in dentistry but in spite of its abundance it is not likely to replace stainless steel for denture marking at present. On the other hand the Ho Band is cheaper, more readily available and it could replace ID-Band for use in Australia. An alternative paper based marking system is also presented together with the rationale for its use. **(J Forensic Odontostomatol 1995 13:1 9-13)**

Keywords: Denture marker, metal strip, radiolucency

INTRODUCTION

The marking of dentures has been carried out over the years to a greater or lesser extent, or not at all, throughout the world. In some countries such as Scandinavia[1] and USA[2] the procedure has been legislated, but in different ways, where it is either compulsory, or optional, and if optional it must be offered to the patient who can then refuse or accept it. On the other hand the number of identifications by denture marks has never been documented and it is not known whether the expense of and time spent in marking dentures is actually justified.

Several systems have been proposed[3,9] and the FDI has adopted as a standard the ID-Band* to be inscribed with whichever code is applicable and suitable for a particular country. In most cases a social security number is used,[1,2] a driver's licence number[2], a national identity number[4] or, for Australia, a name and postcode have been suggested.[5] Denture marking in the latter country is not carried out to any extent in a systematic way and has not been legislated. International recognition of the mark however always presents difficulties and is an important consideration as worldwide travel increases in volume.

It is generally believed that denture marking would be very low in the priority list of health legislation of governments, particularly in the present difficult economic times, and in Australia can all but be disregarded. If it is then to be taken up voluntarily by the profession it has to be at absolutely minimum cost and time and a system and materials accordingly found.

Acrylics and porcelains used to fabricate dentures are very resistant to most degenerative processes[6] with the notable exception of fire. However if dentures are retained in the mouth very little destruction takes place,[7-11] even in the most severe bodily incineration.

In the light of these observations the quest for a cheaper and a more logical denture marking system continues. In this paper tests of alternative metal foils and also a rationale for not using metal foil at all will be presented.

MATERIALS AND METHODS

Three metal foils were prepared for tests including tensile strength (at MPa), strain at break (%) and elongation (%). A tensile testing machine† was used and specimens were pulled to destruction at room temperature and after exposure to 700°C and 900°C. The foils tested were commercially pure (CP) Ti¥ (9 μm thick) and two 18-8 stainless steel foils (both 3 μm thick) (ID-Band* and Ho Band§). Between 4 and 7 specimens of each metal were pulled to break point and the data fed to a PC for direct processing to a printer and visual output to a monitor (Fig.1).

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* *SDI, Upplands Väsby, Sweden*
† *Autograph AG-50k NE, Shimadzu, Kyoto, Japan*
¥ *Kobe Steel, Kobe, Japan*
§ *Lorvic Corp, St Louis, USA*

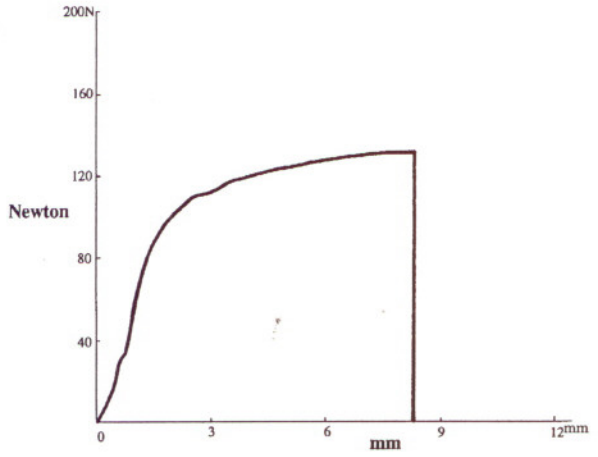

Fig 1 A typical stress/strain curve obtained by pulling the specimen to destruction (Ho Band after heating for 30 mins at 900°C)

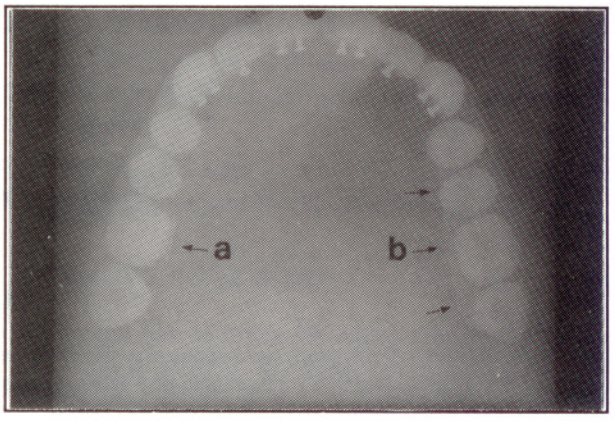

Fig 3 The denture containing 2 strips of Ho Band foil. (a) coiled and (b) flat.

The results were analysed statistically by Student's t-Test with significance levels of 95% and 99% respectively.

Radiography

The three strips of foil were radiographed on a single periapical dental film¶ at 70Kv (7mA) for 0.5s with a conventional dental X-ray machine# (Fig.2). Two strips of Ho Band were then inscribed by typewriter and incorporated into the acrylic of a maxillary complete denture for radiography. One was laid flat, the other was tightly coiled, and each was positioned under one of the first molars. This was done during the processing and after finishing the denture in the usual way it was radiographed on an occlusal film** (Fig.3).

Incineration

The denture was then placed in a porcelain crucible and fired at 600°C for 2 minutes after which all the resin had been consumed and only the porcelain teeth and the 2 metal strips remained. These were gently recovered, the coiled strip unrolled and both placed in a 1:10 dilution of hydrochloric acid. An unsuccessful attempt was made to read the inscription (Fig.4).

¶ *Kodak, Rochester, USA*
\# *Siemens, Germany*
** *Autograph AG-50k NE, Shimadzu, Kyoto, Japan*

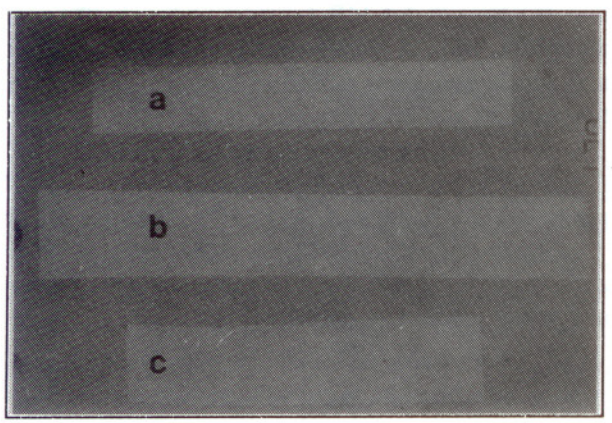

Fig 2 The three strips of foil were radiographedon dental film and by conventional dental X-ray machine.
(a) ID-Band,
(b) Ho Band and
(c) titanium foil

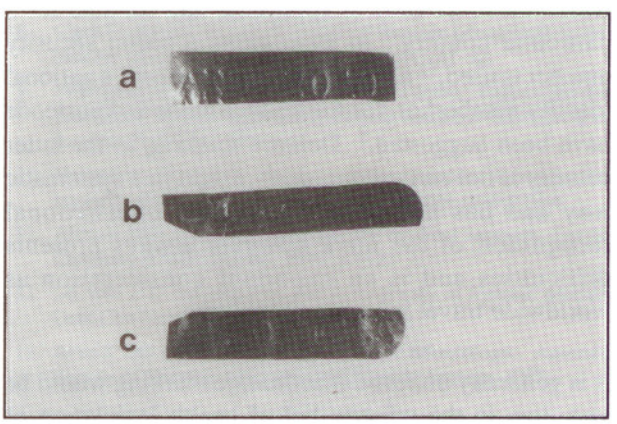

Fig 4 Ho Band after denture incineration at 600°C.
(a) an unincinerated example
(b) the flat foil,
(c) the coiled foil.

RESULTS

1. Tensile strength

Table 1 shows the mean tensile strength in MPa for the three materials. Significantly higher values at all temperatures were recorded for the Ho Band, particularly at 900°C.

Table 1

The mean tensile strength of the three foils measured in MPa (asterisks denote significant difference between the adjacent means on t-Test)

	n	Titanium	n	ID-Band	n	Ho Band
Room Temperature	3	348.33 ± 4.73 *	5	432.00 ± 24.35 **	4	850.00 ± 19.61
700°C	4	352.00 ± 2.94 -	4	442.75 ± 92.00 **	5	840.80 ± 37.14
900°C	3	249.67 ± 54.35 *	4	459.75 ± 1.89 **	6	880.83 ± 41.22

* $p < 0.05$ ** $0 < 0.01$

2. Strain at break

The behaviour of the two steel bands was not significantly different except for RT but titanium had a very low break point at 900°C (Table 2).

Table 2

The percentage mean strain at break point of the three foils (asterisks denote significant difference between adjacent means on t-Test.)

	n	Titanium	n	ID-Band	n	Ho Band
Room Temperature	3	26.50 ± 2.65 -	5	32.64 ± 8.52 *	4	63.65 ± 10.88
700°C	4	14.53 ± 1.26 *	4	56.13 ± 17.55 -	5	62.98 ± 12.43
900°C	3	4.5 ± 0.30 **	4	58.43 ± 5.11 -	6	57.33 ± 8.35

* $p < 0.05$ ** $0 < 0.01$

3. Elongation

Once again the greatest difference encountered ($p<0.01$) was between the Ti and the steel at 900°C (Table 3).

Table 3

The mean tensile strength of the three foils measured in MPa (asterisks denote significant difference between the adjacent means on t-Test)

	n	Titanium	n	ID-Band	n	Ho Band
Room Temperature	3	17.60 ± 2.17 -	4	23.90 ± 7.20 *	4	44.18 ± 9.20
700°C	3	6.27 ± 0.95 *	3	46.40 ± 6.24 -	5	33.80 ± 9.31
900°C	3	0.17 ± 0.68 **	4	42.55 ± 4.94 *	6	28.03 ± 6.04

* $p < 0.05$ ** $0 < 0.01$

4. Radiography

   No quantification was done of the radiolucency of the foils. The three unprocessed specimens were all of equal density and were quite radiolucent, which was to be expected because of the thinness of the metal, although the Ti foil was three times thicker which is an indication of its natural radiolucency. The image of the foil within the denture was faint but visible in spite of overlapping porcelain teeth.

DISCUSSION

Requirements for a metal denture marker are that it must be soft and plastic enough at room temperature to be easily indented by typewriter or ball-point pen during the inscribing process and if necessary must be moldable to fit a cavity or rolled up and retain its coil. It must further be resistant to corrosion and fire and it must possess a high strain at break and a high tensile strength after exposure to high temperature. This would reflect in the ability to handle a foil strip after firing. The three foils displayed different reactions and in all requirements except resistance to corrosion the Ti foil was inferior. The steel bands both reacted similarly but their significant difference in tensile strength ($p<0.01$ at all temperatures) is difficult to explain in view of their similarity of composition. The Ho Band is primarily a dental matrix band and it is natural that it should possess high tensile strength for that purpose. It should also have high elongation. A method for hiding the mark has been proposed in which the foil is rolled into a compact dimension and then incorporated into the denture base acrylic resin during processing. This effectively removes it from view and while this satisfies possible privacy requirements it does mean it could be missed. A non-destructive method of finding it is by radiography, and the test revealed the foil both rolled up and laid out straight. The fact that all three foils were equally dense makes them equally acceptable but it was inevitable that they should not be very opaque. The Ti foil was thicker than the steel but experience with the radiography of Ti partial denture frames compared with C/Cr shows that Ti is more radiolucent and the above result was to be expected.

The cost of the Ho Band in Australia is considerably less than the ID-Band and that is a strong factor in its favour. The Ti foil does not match up in most of the desirable properties and can therefore be disregarded.

The argument against using a metal marker

It has repeatedly been found that a denture which remains in the mouth during an incineration is very well protected and at least the posterior 1/2 to 1/3 will stay intact. Any mark which is present, including one which is not fire resistant, will thus survive. However when the denture is expelled from the mouth as often happens in violent accidents such as air crashes,[12] and there is a fire, that denture will be destroyed but not its marker, if fire resistant.

This delicate and insignificant little metal strip will now join the considerable other debris that will inevitably be present. Is it at all conceivable that there is time, the incentive, the skills and the hands to find it, and who would know that there had been a strip to look for? and then, in the unlikely event of it being found, would anything be readable?[13] This author believes not and must therefore come to the conclusion that even when there is fire a fire resistant material is probably unnecessary. Vestermark[7] suggested that an aesthetic paper strip will be adequate and a trial with a piece of adhesive label (Fig.5) shows that it is in fact quite acceptable. Its cost and manipulation is of course far more reasonable and is more likely to gain favour when its acceptance depends upon voluntary implementation.

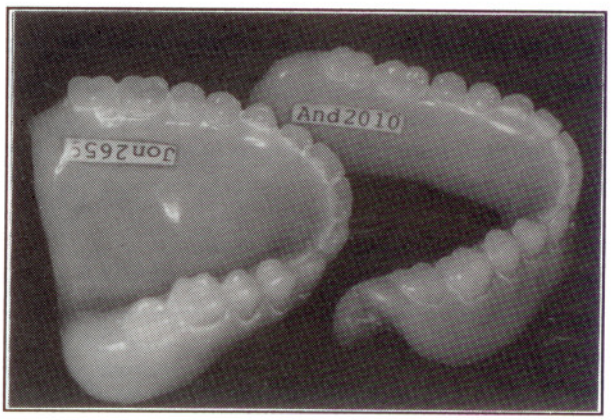

Fig 5

As the century draws to a close and global economic thinking tends more and more to a user pays, fiscally stringent philosophy and where high productivity, quality control and ruthless pruning of expenditure are the essence of financial management the marking of dentures without supporting data for frequency of involvement in an identification will be more and more difficult to justify. These data should be available before further moves to introduce denture marking are taken.

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DENTURE MARKING
Clinical and technical aspects

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ABSTRACT

The frequency of edentulousness has decreased in recent years due to the improvement in oral health. However, there is still a need to address the issue of denture marking for social and legal reasons because the oral status of populations varies in different countries and the wearing of complete dentures will be a fact for the foreseeable future. Given that only one marked denture can tell us the identity of a deceased when all other methods fail makes it a worthwhile exercise. The marking of dentures is not regulated by law in Sweden, but it is recommended by the Swedish Board of Health and Welfare (SOSFS[M]1986), that all patients should be offered the opportunity to have their dentures marked, which they may refuse. In Sweden, the dental laboratories report that they mark all dentures. The Swedish ID-Band has become the international standard and FDI accepted denture marking system, but recent research has indicated that this metal band is not resistant to very high temperatures. Since there is no international consensus regarding the matter we suggest that new materials should be explored. **(J Forensic Odontostomatol 1995 13:1, 14-17)**

Keywords: Dentures, marks, metals, allergies, disasters.

INTRODUCTION

The oral status of populations varies from country to country and considerable differences are found even in Europe. Although the frequency of edentulousness has decreased in recent years due to the improvement in oral health,[1] there is still a need to address the issue of denture marking since it is more difficult to identify an edentulous person than a dentate one.[2] In the age groups older than 70 years in the UK in 1988, the percentage of edentulous persons was 80 per cent[3] while figures were lower for the Nordic countries,[1] especially in males.[4] Thus, reports of the frequencies of edentulousness and use of dentures can be variable and will depend on size, location and age of population examined.

A mark in a denture which is legible is extremely valuable in identification of human remains. Consequently, as pointed out by Thomas,[5] in the absence of natural teeth dentures can only be of equivalent value if they are marked. It has been well documented that dental stone casts derived from maxillary tissues can be successfully matched to the morphology of the internal aspects of maxillary dentures.[6,7,8] Unfortunately however, it is difficult to retrieve the stone casts intact after denture processing, but a duplicate casts or an old denture can serve the purpose. Available data indicate that the marking of dentures ranges from 2.5%[9] to 47%[10] in certain countries. Thus, in a ten-year survey of all forensic odontology cases in Stockholm, Sweden,[11] it was reported that only 19% of the dentures were marked, but over the years the police, coassisted by forensic odontologists, have still been able to identify persons from their dentures when they were in place in the mouth. The assistance of trained forensic odontologists seems to be valuable since it has been reported in another part of Sweden that one person was initially misidentified because the victim had borrowed a denture!

Haines[12] reported that among 380 air disaster victims there were 97 dentures and only seven were marked. In another report of an air disaster by the same author[13] five edentulous victims remained unidentified because there were no markings on their dentures. In 1991 Clark[14] described the dental identification in the Piper Alpha oil rig disaster in which 28 of the 136 victims had dentures and 11 of those were complete uppers and lowers. He does not mention denture marks or identification of dentures. A recent review of mass disaster victims during the last ten years[15] has revealed that the number of denture wearers was 48 among 464 victims in five big disasters with most of the dentures unmarked. In the Bradford disaster in 1985[9] 38% of the victims wore dentures of which only one was marked. While dentistry contributed to identification in 58% of the victims, this would have increased to 82 % had all the dentures been identifiable. One victim from the King's Cross station fire (1987),[15] wearing complete dentures, still remains unidentified. This case clearly demonstrates the need to mark dentures with at least the owner's name not only for humanitarian and legal purposes but also to minimize the cost of identification. Identification by denture marked with a metal band after a house fire is shown in Fig.1.

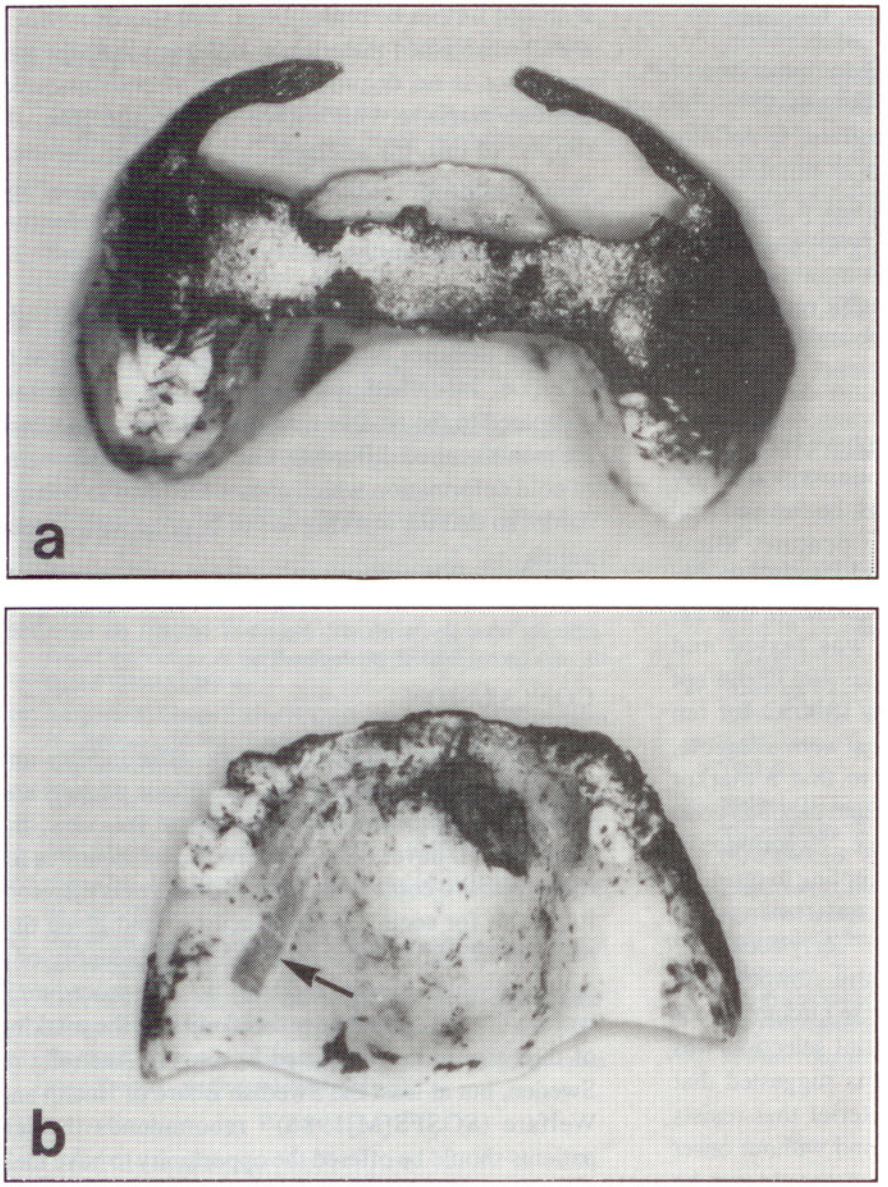

Fig 1 A case of identification by a marked denture from a severely burned body after a house fire in Göteburg, Sweden. The denture was marked with a readable stainless steeel band. (a) anterior view, (b) posterior view with mark (arrowed).

The aim of this article is thus to discuss clinical and technical aspects of denture marking and to address the questions: why and with what should dentures be marked?

CLINICAL ASPECTS

An investigation carried out by the Swedish National Social Insurance Board in 1974 showed that marking of dentures was more common in public (58%) than in private dental care (4%).[16] Nowadays, the dental laboratories in Sweden report that they mark all dentures,[10] but other recent data from a study of dentures and denture marking in old people's homes in the Göteborg area revealed that only about half of the dentures were marked,[10] one of the reasons for this lower incidence being that patients can refuse denture marking. Harvey[17] suggests that in these cases invisible ink may be used. We believe however that if the patients are properly informed about the purpose of the marking they will have no objection. This is supported by Johanson and Ekman[18] who reported not experiencing any refusal to have a denture marked. This is important because the mark will prevent the dentures from being lost or inadvertently intermingled in institutions. Dentures are often propelled from the mouths of aircrash victims[19,20] where there could be destruction of the jawbones in the consequent fire. Furthermore, from a forensic point of view, it is important to know the number of denture wearers among the victims of a mass disaster.

Even though the Swedish ID-Band* has become the international standard and FDI accepted denture marking system there is a need to reassess it as it is not available in some parts of the world or is too expensive.[21] Recent opinion has it that international collaboration and consensus are needed to find the best procedure and material for the marking.[21,22]

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TECHNICAL ASPECTS

Different methods of short- and long-term marking of dentures have been suggested over the years.[5,18,21,23-26] Some of the methods have been illustrated in A Color Atlas of Forensic Odontology[27] and in its simplest form the patient's name is printed on a tissue paper and incorporated into the denture. For forensic purposes however this is not sufficient because the marking material should fulfil many more specific requirements and in this article we will discuss these and the question of long-term marking of dentures.

The requirements of a denture marker have been clearly stated[18] and should contain an inscription which is easy to read, be inexpensive, easy to insert, be fire and acid resistant, should not weaken the denture, allow subsequent relining or repair and be aesthetically acceptable. Subsequent research[22] has shown that the stainless steel ID-Band which was tested and recommended by Johanson as early as 1963[28] did not fulfil the requirement of resisting 1300°C for ten minutes as at 1150°C the markings were illegible. However to decide the temperature that a marker material should withstand is difficult and depends upon conditions present at a particular time. Experience of past disaster fires is important in attempting to quantify these temperatures and at a recent testing and simulation of the "Scandinavian Star" ferry accident[29] it was revealed that the maximum temperature approached these values, but that these circumstances were extreme. The matter of material selection was addressed in a previous paper.[30] It is suggested that the dentures be marked with a material that resists 1300°C without structural changes and without onset of oxidation (scaling). The material should not be brittle, be easy to insert and should have properties that should make it obvious and easily recoverable from surrounding debris.

In order to avoid Ni exposure as a potential allergen, the SDI company has discontinued marketing the ID-Band in Sweden and Australia in favour of a Ni-free product, but the ID-Band is still sold in the United States. The result in Sweden has been that some dental laboratories have ceased to mark dentures, whereas others use Remanite* or the Ni-free material. Unfortunately this has meant switching from one stainless steel grade to a similar but harder material.

The attempt to avoid Ni-containing stainless steel incorporation in dentures seems to be over-cautious since the ID-Band is well embedded in the acrylic. It should further be remembered that stainless steel is a well established material for orthodontic appliances and there is no documented case of stainless steel denture markers which have caused allergies. In support of this, the allergenic properties of materials in prosthodontics containing Ni have been tested and found negligible[31] and its relevance for denture marking has been discussed elsewhere.[30]

The main reason for some laboratories choosing not to mark dentures is that the ID-Band was simple to use (i.e. inscribed with an ordinary typewriter) compared to the Ni-free material and Remanite which are manufactured differently and involve a high degree of cold deformation which causes the band to become harder so that the marking has to be done with a metal punch.

CONCLUSION

Since there are differences in the affordability and availability of dental care for edentulous persons and that only a few have access to dental implants, the majority will have to accept conventional dentures for many years to come. Marking of dentures is therefore important for social and legal reasons and given that only one marked denture can tell us the identity of a deceased when all other methods fail, the procedure is worthwhile. It should be pointed out that the marking of dentures is not regulated by law in Australia or Sweden, but at least the Swedish Board of Health and Welfare (SOSFS[M]1986)[32] recommends that all patients should be offered the opportunity to have their dentures marked, which they may refuse. In Sweden denture marking is included in the total cost of making a complete denture. From a forensic point of view it is necessary to find and to use the most suitable identification marking band which should have both clinically and technically acceptable qualities. Since recent studies have indicated that the metal bands accepted by the FDI as a standard denture marking system are not resistant to very high temperatures, we suggest that new materials should be explored.

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