J Forensic Sci, September 2006, Vol. 51, No. 5
doi:10.1111/j.1556-4029.2006.00238.x
Available online at: www.blackwell-synergy.com

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Contemporary Methods of Labeling Dental Prostheses—A Review of the Literature

ABSTRACT: Forensic identification (ID) based on an assessment of the dentition is common place. However, despite an increase in the oral health of Western populations, there are still many millions of individuals who are edentulous and whom have been treated with completed dentures. In the United Kingdom alone over 300,000 patients are rendered edentulous each year. In order to facilitate the ID of such individuals a number of forensic and governmental organizations have recommended that dentures be labeled. A number of labeling systems exist which can be broadly separated into inclusion systems, marking systems, and novel methods. Each of the commonly described systems are demonstrated with an assessment of their strengths and weaknesses. It is recommended that an inclusion denture marker, preferably metallic, should be used in order to withstand the most common postmortem assaults.

KEYWORDS: forensic science, dentures, prostheses, labeling, identification, dental

Following major disasters such as earthquakes, fires, or floods, a definitive and early identification (ID) of the dead and injured becomes of the utmost importance. Often this ID must be accomplished via some form of forensic dentistry (1). Determination of the various individual physical and genetic characteristics of the human dentition has proved to be very efficient in aiding the task of ID (2,3). Edentulous subjects, on the other hand, have lost all or most of the key features that have proven valuable in such cases, hence the process of ID is made much more difficult unless the victims wear ID marked dentures (2). ID of badly mutilated bodies, or bodies burned beyond all recognition, can usually be made if labeled dentures are present. The dentures generally remain undamaged owing to the protection afforded them by the soft tissues of the oral cavity (4). Following the Bradford football fire (U.K.) on May 11, 1985, the first of 20 recommendations made by the inquest jury was "... clearer marking of dentures, preferably with the name of the owner, should be mandatory" (5). Therefore, the aim of this literature review is to report on the various methods of denture marking, both past and present, in a bid to determine the most efficient means of facilitating postmortem ID of the edentulous individual.

The concept of personal ID from dental prostheses has been around for hundreds of years. The earliest recorded cases of ID involved single cases, i.e., people who had met a sudden death (6). Turner et al. (7) reported that the Countess of Salisbury, who burned to death in the west wing of Hatfield House in 1835, was identified via her gold denture; the authors also stated that the identity of the body of a Dr. Parkman from Boston, Massachusetts, U.S., was able to be determined from fragments of mineral teeth fused to his gold denture base.

ID marks on dental prostheses serve two main functions. First, they facilitate the ID of the patient from the denture, e.g., in such cases of unconsciousness, loss of memory or for forensic purposes. Second, the ID of the dentures of the living patient, which would not only be helpful for the production laboratories but also for institutions such as hospitals and community homes (10).

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Received 4 Mar. 2006; and in revised form 28 May 2006; accepted 11 June 2006; published 15 Sept. 2006.

Requirements of an Identity System

An ideal denture marking should fulfil all of the following ideal criteria (7,8):

(1) The mark carried by the denture must be capable of yielding positive ID.
(2) The marking technique must be easy and quick to carry out and cheap to introduce bearing in mind the requirements of (1) above.
(3) The mark should, ideally, be fire resistant, and if it is not, it must be placed palatally or lingually in the molar region, so that the tongue can protect it.
(4) The marking method should not affect the durability of the denture base material.
(5) The mark should be cosmetically acceptable to the patient, and as unobtrusive as possible.

Dentures containing some form of identity mark have proved to be of great benefit (9). Over the years various denture marking systems have been reported in the literature and have been divided broadly into "surface marking" and "inclusion methods."

Surface Marking Techniques

In this method, ID marks are scratched, engraved or written onto the surface of the denture or denture cast. Heath (10) employed a method of writing on the surface of the denture using a spirit based pen or pencil before covering the ID mark with a clear denture base polymer dissolved in chloroform (Fig. 1). This method of denture marking certainly satisfies the criteria for an ideal denture base marker in terms of simplicity and cheapness; however, it does have one or two disadvantages. Firstly, the ID mark possesses poor abrasion resistance and hence cannot be considered permanent. Secondly, chloroform is a known carcinogen and hence it is axiomatic that a noncytotoxic solvent should have been used.

FIG. 1—*The Heath method of surface marking dentures using written markings covered by transparent denture base polymer.*

A more durable and cheaper way of denture marking was described by Stevenson (11) in which a scalpel blade is used to scribe a serial number on the distobuccal flange of the denture. The mark is then highlighted with a graphite pencil (Fig. 2). The technique was developed by the Columbus Society Operation Ident. Committee and used to mark 275 dentures for residents at 16 nursing homes during Operation Ident. in 1982. The author states that technique was deemed successful owing to the fact that no problems or complaints had been reported. This last comment appears somewhat surprising as the technique appears quite crude, unaesthetic, and possesses poor potential in terms of plaque and fire resistance.

The final surface marking technique involves scribing an ID mark directly into the working cast before denture processing. This negative mark cut into the cast produces a positive embossed ID mark on the fitting surface of the processed denture. However, this type of ID mark has proved less popular owing to the fact that it can cause irritation of the patient's mucosal tissue and again, may result in a plaque trap that may contribute to candidal infections (7).

Inclusion Techniques

In contrast to surface marking techniques, inclusion methods enclose the identifying marks within the denture base material,

FIG. 2—*Stevenson surface marking technique in which the details are scratched onto the surface of the denture.*

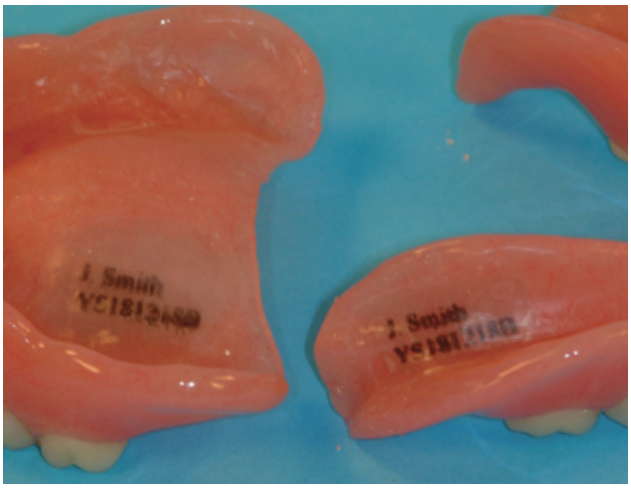

FIG. 3—*The Lose inclusion technique in which "onion skin paper" is placed within the denture. Such systems afford little protection against perimortem assaults such as fire.*

hence rendering them relatively permanent. Lose (4) described one such method in which the patient's name is typed on a piece of "onion skin" paper such as that used to separate sheets of baseplate wax. The acrylic resin fitting surface situated adjacent palatally between the ridge and the center of the palate is moistened with monomer on a small brush. The strip of typed paper is laid on this surface and the paper moistened with the monomer. Clear or pink polymethyl methacrylate (PMMA) is then placed over the paper before final closure of the denture flask (Fig. 3). The author describes the method as "simple, nontime consuming, and effective." However, latter would only appear accurate assuming that no perimortem assaults occurred; for example such a system would be ineffective against fire.

A variation of the method described by Lose was introduced by Ling (12) in which a typed onion skin label was used. In this method white typing correction paper was used to form the characters instead of conventional ink. The position of the label differed also from that chosen by Lose in that it was situated inferior to the posterior teeth under the polished surface of the palate. This technique was criticized by Furst (13) owing to the fact that as the label consisted of a simple piece of typed paper, it would be unlikely to survive a fire. Instead for forensic purposes, he advocated the use of a metallic strip 0.001 in. thick, suggesting that it would be more likely to withstand thermal insult.

Ling's white character method suffered from a major problem in that it fell victim of the development of computer technology. The exponential rise in the use of electronic word processing and printer technology in the 1990s rendered mechanical typewriters redundant; hence there was no longer any need for typing correction paper. However, in 1998 the author modernized the method by describing the use of a computer printed label that could be photocopied onto a transparency film (14). The photocopied characters were then coated with cyanoacrylic acid (superglue) in order to protect them from the solvent effects of the denture base monomer prior to incorporating the label into the denture during the packing procedure.

A variation of this technique was reported some 2 years earlier by Ibrahim (15) who used labels printed on 35 mm photographic slides via the use of a computer graphics package, a Polaroid digital Palette slide maker and associated software. A character with a font size of 22 was used to produce a readable label measuring

FIG. 4—*The inclusion technique of Ibrahim using transparency film enclosed within the denture base.*

15 mm × 3 mm. The processed slide is then cut to the correct size before being placed into a space 1 mm in depth before being covered by clear auto polymerizing resin (Fig. 4). The resilience of this film to fire is greater than that of the previous paper techniques, but distortion of the film can occur at relatively low temperatures and therefore it offers only a moderate improvement over Lings' earlier work.

A less sophisticated alternative in terms of technology was proposed by Fiske et al. (16) in which the authors described a method which involved sticking a piece of 1 mm metal relief metal foil onto the maxillary cast just below the posterior teeth prior to cold mold sealing; the denture processing is then continued as normal. Subsequent to deflasking, the metal strip is removed from the surface of the denture, leaving a flat, smooth 1 mm recess. A fine draughtsman's drawing pen is used to print on the acrylic the patient's name and/or other details. The recess is then filled with clear auto polymerizing resin before being trimmed and polished in the usual way.

The authors claim that the method provides permanent marking and adds only *c*. 5 min of the technician's time to the total flasking and polishing procedure. Such a method may well prove to address the needs of fire resistance, although the overall time taken in the laboratory is likely to be in excess of the 5 min claimed.

A postfabrication alternative was described by Berry et al. (1) in which a specially designed depth limiting bur is used to cut a 4 mm wide by 1 mm deep recess into the polished surface of the finished denture. A laser printed label, usually onion skin is then placed into the recess before being covered with a layer of either clear self-cure PMMA or light cure resin The obvious advantage of this, and similar postfabrication labeling techniques is that they are retro-fittable, i.e., they can be applied to existing dentures at a later date should the patient and/or dentist wish to do so.

A method similar to that described by Berry was first reported by Coss and Wolfaardt (17) and then by Bernitz and Blignaut (18). However, in their technique the ID labels were produced in a "P-touch" electronic lettering system (P-touch, Brother Co., Dollard des Ormeaux, Quebec, Canada). The labels used consisted of a 103 μm thick, white or clear laminated strip onto which 2 mm characters were typed (Fig. 5). The finished label could either be included pre- or postfabrication and, according to *in vitro* studies, when embedded in acrylic, the labels appeared resistant to substances such as tea, coffee, saline, acetic acid, and 3% peroxide.

A much simpler postfabrication technique reported by Young (19) involved cutting a groove of *c*. 0.5–1 mm deep into the buccal

FIG. 5—*The Coss and Bernitz labeling system using a laminated strip.*

flange of the denture; the length of which would correspond to the length of the patient's name. An ordinary ballpoint pen or felt-tip pen is then used to print the patient's name in the recess before being sealed with fissure sealant (Fig. 6). The technique is described as relatively inexpensive in terms of material cost; however, apart from aesthetic considerations, it suffers from the same problems as all of the aforementioned methods in that it is debatable as to whether the writing would be capable of surviving a major fire in which only fragments of body remain. Despite this rather obvious flaw, many workers still perused the concept of developing labeling methods utilizing nonmetallic materials.

Oliver (20) described a system which involved producing a label comprising a thin strip of PMMA. The technique involved pressing a mass of heat-cure resin dough between two halves of a denture flask. By not closing the flask completely, a sheet of resin *c*. 0.3 mm is produced. The flask is then heat-cured for 10 min at 90°C. A fine fiber-tipped pen is then used to mark the label before including in the fitting surface of the denture base during the trial packing procedure. A variation of this method was reported by Lamb (21). The production of his label involved curing a mix of clear auto polymerizing resin between two glass slabs separated by 0.25 mm wire spacers. The label would then be marked and incorporated into the denture in a similar manner to that of the previous author's description (Fig. 7). This method offers little in the way of protection from perimortem assaults and is costly in terms of laboratory time.

Luebke and Unsicker (22) and Toolson and Taylor (23) used heat shrink plastic strips to produce ID labels. The patient's details

FIG. 6—*Young's technique involves writing in a recessed area of the denture which is then covered by transparent resin.*

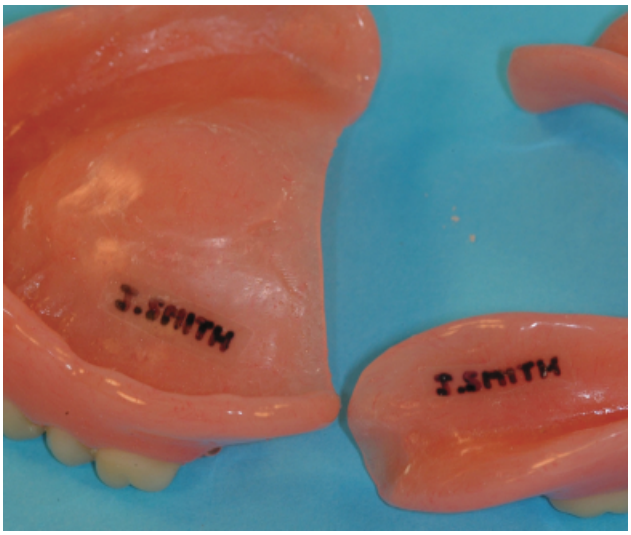

FIG. 7—*Oliver denture technique which employs a 0.3 mm sheet of resin.*

would be either written or typed onto the strip before being placed into an oven at 250–325°C for *c*. 30 sec. The strip would then shrink down to approximately one third of its original size incurring, little distortion to the inscription (Fig. 8). A recess corresponding roughly to the size of the strip would be cut into an aesthetically acceptable position in the denture; the strip is then placed into the recess and covered with auto polymerizing resin. The denture would be trimmed and polished as per normal (Fig. 9). This method is compact and aesthetically pleasing but fails to meet all the requirements of denture labeling by being susceptible to fire and also to a variety of denture cleansers, should the covering resin become compromised.

A rather cumbersome method of labeling was reported by Chalian et al. (24) and also by Ryan et al. (25) which involved the fabrication of a T-shaped clear PMMA resin bar. The bar is constructed by cutting baseplate wax into $\frac{1}{4}$ in. strips. One of the strips would then be positioned edge-ways against the midline of its neighbor to form a T-shaped bar. The bar would then be flasked, packed, processed, and finished in clear PMMA. A section of the bar would be cut to the required length and a typed label (reduced in size) attached print-face inward against the flat section of the bar (Fig. 10). The bar would then be either incorporated into the wax denture prior to flasking or fitted into a suitably prepared recess in the finished denture. Finally, the leg of the

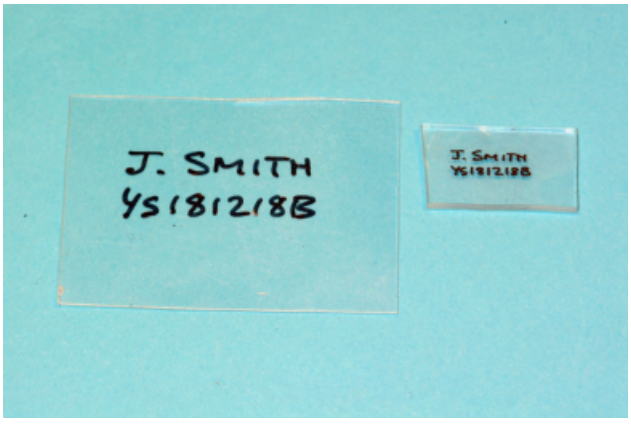

FIG. 8—*Luebke and Unsicker technique in which heat shrinked plastic strips are employed to produce clear but compact labels.*

FIG. 9—*The Luebke label is inserted into the denture and polished as usual.*

"T" could be ground away and remaining surface polished to produce a clear window displaying the ID label (Fig. 11). From this description, it would seem reasonable to assume that this technique would not only time consuming but the end result would perform no better than any of the aforementioned methods in terms of aesthetics and fire resistance.

A technique in which soft rolled metal bands were buried in fabricated dentures was described by Dippenaar (26). The author describes a method in which a standard soft metal band is either typed or engraved with the patient's details before being rolled up and inserted into a predrilled cavity *c*. 2–3 mm wide (Fig. 12). A small wax plug is then placed over the metal band prior to filling the remainder of the cavity with self-cure resin. Upon first inspection this method appears superior to that of other inclusion methods in terms of aesthetics and fire resistance, however, the technique was criticized by Bernitz (27), stating that ". . . it is of no value in day to day ID as the marking is not readily visible."

One postfabrication inclusion method that appears to satisfy all of Vestermark's criteria was reported by Thomas (28) and later by Johanson and Ekman (29). The method requires the use of a typewriter, minus its ribbon, to print the patient's details onto a commercially produced metal strip (trade name: ID-Band). The band purports to be both fire and acid proof and comes with its own depth limiting bur as part of the kit (Fig. 13). The label is positioned into the recess created by the depth limiting bur, covered with clear self-cure resin, finished and polished as per standard practice (Fig. 14). Rather surprisingly, although this technique may be superior to many of the aforementioned methods in terms

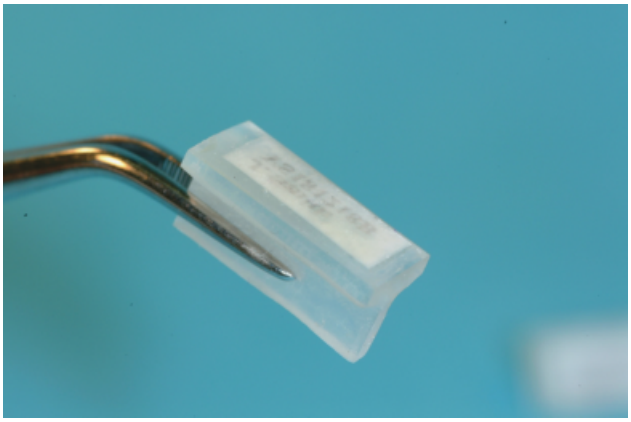

FIG. 10—*Chalian "T"-shaped resin bar containing an identification label.*

FIG. 11—*The resin "T" bar is incorporated into the denture and polished to provide a clear window displaying the identification details. A complex, time consuming, and fire susceptible method of denture identification.*

of fire resistance, the ID-band identification kit is still readily available to-date despite the fact that the typewriters are no longer commonplace, having been largely replaced by laser and inkjet printers.

Reeson (30) reported another denture ID method utilizing a metal substrate. This author's solution to the ID labeling problem involves the use of a piece of 0.125 mm thick stainless steel tape onto which the patient's details are engraved. The tape is then incorporated into the fitting surface of the denture during the trial packing stage (Fig. 15), and, according to the author, the procedure has proven to be reliable over a long period. Nevertheless, one disadvantage emerges if relining becomes necessary, i.e., an increase in opacity produced by an increase in palatal thickness, however, this can be overcome if the denture is relined in clear acrylic resin, which will allow the ID plate to remain visible.

One of the major drawbacks common to all of the methods reviewed so far relates to the limitation of actual amount of data that can be written onto an ID label. Fonts of a conventional size (i.e., 10–12) only allow information such as the country code and personal ID numbers to be accommodated, but fonts of size 6 or smaller would easily allow the person's name, gender country of origin, and personal ID number to be included. Ling et al. (31) described a method employing a high-power copper vapor laser in order to maximize the amount of data that can be written onto a metallic ID label. Using such a device font sizes of a microscopic level can be produced and hence allowing far greater amounts of data to be recorded; even on small objects such as a metal crowns. However, mindful of the obvious, the authors stated that the initial cost of the setting up of this very bulky looking device is high but also say that the cost of engraving is negligible. Another disadvantage identified is the warm-up time of the laser prior to its operation; *c*. 45 min (31). Hence although both the miniaturization and quantity of the data that is able to be written is vastly superior to any of the labeling systems identified so far, it is self evident that this high-tech solution would more than likely be out of reach of the many dental laboratories and/or dental practitioners in terms of monetary investment (31).

FIG. 12—*A metal identification roll being placed into a prepared cavity. When completed the roll is invisible and hence not easily detected for forensic or clinical use.*

Another high-tech denture marking technique was investigated by Rajan and Julian (32) which involved a rather unconventional use of electronic microchip manufacture technology. Using conventional production methods, the chip manufacturer would etch electronic circuitry onto a base laminate circuit board composed of high quality woven E-glass sandwiched between epoxy resin with copper cladding. However, in this case, instead of electronic circuitry, the author's had the patient's information etched onto a chip measuring 5 mm × 5 mm × 0.6 mm. Hence instead of conducting an electrical current the chip was used purely as a miniaturized substrate for written information. Nevertheless laboratory tests conducted on chips embedded in acrylic resin appeared to perform well under such conditions as thermal insult, etc., in which they withstood temperatures up to 600°C, had excellent acid resistance and was not only radio-opaque but bonded well with acrylic resin. However, the authors stated that the main disadvantage of the chip was that it could only inscribed by the manufacturer and not by the dentist. In 1999 Rötzscher et al. (33) used the microchip for the purpose for which it was intended i.e. storing information electronically. In their study, the authors placed a microchip measuring 4 mm × 4 mm × 1 mm into a complete upper denture. Additional equipment required comprised: a hand-held Psion workstation, 128k flash SSD including software, two batteries and a read/write pen for data transfer to a PC. Patient's information was transferred to the chip via the read/write pen and backed up via an SSD and/or a PC to ensure data preservation. Patients, information included such details as: surname, first name, and insurance number (33).

Upon first inspection this method of ID marking appears to show a lot of potential, in terms of the quantity and quality of information that may be stored, however, as the authors failed to provide any relevant data pertaining to postmortem insult such as heat/cold resistance or electric shock, etc., the technique cannot be fully assessed (33). A further development in the field of electronic ID was reported by Millet and Jeannin (34). In their study the authors implanted a radio frequency ID (RFID) transponder into a complete upper denture.

Their RFID system consisted of a data carrier, generally known as a tag or transponder, and an electronic handheld reader. The tag consists of a torpedo shaped microchip with a coiled antenna, measuring 8.5 mm × 2.2 mm (Fig. 16). The transponder contains no batteries and is hermetically sealed in a protective tube. The tag is maintenance free and purports to have an unlimited life span. The reader energizes the transponder by means of an electromagnetic field emitted via the reader's antenna. It then receives the coded signal returned by the transponder and converts it into readable data (34) (Fig. 17). The authors chose to use a read/write over a read only tag so that the data could be modified in such instances as, e.g., a change in room number for hospitalized or

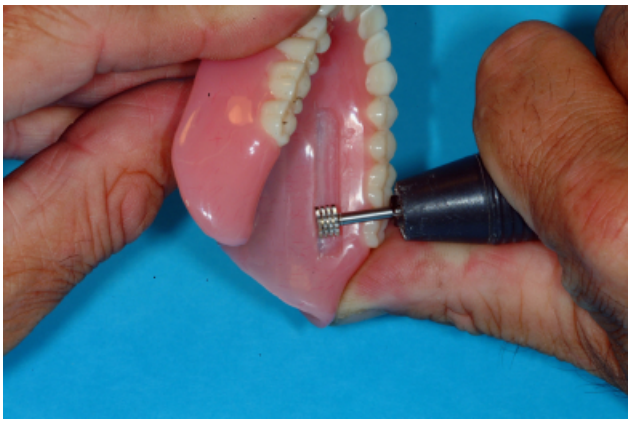

FIG. 13—*A depth limiting burr being used to produce a cavity for a metal identification band.*

FIG. 14—*The completed metal identification-Band* in situ.

institutionalized patients. The data are stored on the chip itself, and does not appear to be altered by standard methods of disinfection, such as ultrasonic cleaners and solutions of 1% hypochlorite, 4% chlorhexidine, and 4% sodium perborate (35,36).

FIG. 15—*The Reeson identification strip in place. Note if the denture has to be relined, the visibility of this strip would be reduced.*

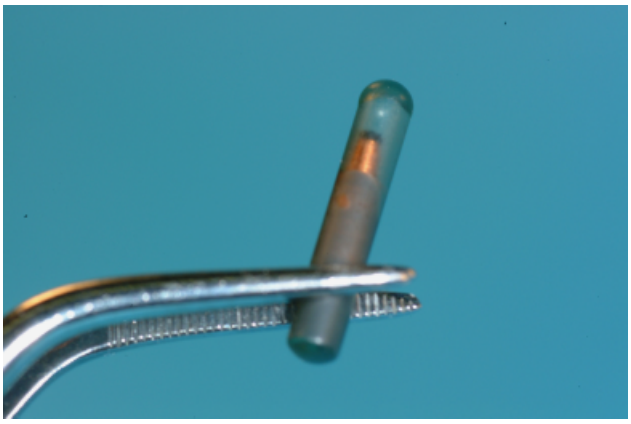

FIG. 16—*A radio frequency identification tag of the type used by Millet and Jeannin.*

However, apart from cost, one disadvantage reported was that device was not fireproof. Furthermore, the authors also stated that this technique involves the use of a handheld reader, which may not exist in every hospital or institution.

Conclusion

Haines (6) reported that among 380 air disaster victims there were 97 dentures and only seven were marked. In another report by the same author (37) citing the Rijeka air disaster, five edentulous victims remained unidentified owing to an absence of markings on their dentures. In the case of the Bradford football ground fire disaster (5) reported that 38% of the victims wore dentures of which only one was marked. The author also stated that while dentistry contributed to ID in 58% of the victims, this would have increased to 85% had all of the victims' dentures been identifiable (5).

Such cases present cogent evidence in support of the argument for the need for some form of denture ID mark, not only for humanitarian and legal purposes but also to minimize the cost of ID (38,39). There are those that would argue that some of the methods of denture ID reviewed in the paper may prove too expensive to be commercially viable, however, it could also be argued that the expenditure incurred in placing denture ID markers is extremely low compared with the cost of replacing a lost denture or the loss of quality of life associated with being dentureless (40).

FIG. 17—*A handheld reader displaying the details of a chip contained within a denture.*

Further research is required to determine the ability for each of these methods to withstand the commonest of perimortem assaults and also which are most favored by patients and dentists. Without the acceptance of denture marking by patients the uptake of any technology will be limited. However, inclusion techniques that employ a metallic labeling system should currently be recommended as they are most likely to withstand the commonest postmortem assaults.

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