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RFID tag with encoded personal information for forensic use, located under a dental filling, a crown or on a dental prosthesis

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Abstract:
Background: *an RFID microchip is an integrated identification circuit that can be implanted subdermally in the body of a living being. The objective of this work is to study the possibility of using a personal identification microchip under a dental filling, a metal-porcelain crown or on a dental prosthesis, for forensic purposes.* ***Material and methods****: labels and marks used in human or animal forensic identification was reviewed. 5 * 5mm Micro FPC NFC Ntag213 programmable adhesive RFID tags and Proxmark 3 Easy were used. Also two natural human teeth, a metal-porcelain crown and an acrylic resin prosthesis where to place the RFID tag.* ***Results****: there are different ways to identify a dental prosthesis. 131 characters of personal information can be written and read on this RFID tag on the teeth and on the acrylic prosthesis. Under the metal-ceramic crown we could not do the same.* ***Conclusions****: the RFID tag located under a filling in a tooth or embedded in an acrylic resin prosthesis is useful for storing encoded personal information and this is of great forensic interest. There are limitations when using this microchip in humans due to lack of privacy and adequate legislation is necessary for its use.*

Keywords: *dental, RFID, proxmark, prosthesis, forensic.*

INTRODUCTION

An RFID microchip is an integrated identification circuit that can be implanted subdermally in the body of a living being [1,2]. Most implants contain three elements: a 'chip' (or integrated circuit), a coil inductor, and a capacitor [2-4]. Standard pet microchips are typically 11-13mm long and 2mm in diameter [2,3]. The veterinarian can inject them without anesthesia and with little discomfort [3]. In some countries this RFID has a number that relates the information to a single official national database [3]. In Spain it is the REIAC (Red Española de Identificación de Animales de Compañía). For medical use, it may also contain a unique identification number that corresponds to information contained in an external database, which would include personal identification, medical history, medications, allergies and contact information [1,2,4] .

In 2007 Hitachi introduced the world's smallest and thinnest RFID chips, measuring just 0.05 x 0.05 millimeters [5]. It can be so small that it allows the tracking of things or people. In this way it could be incorporated into thin paper such as cash paper money [5]. The microchip can be injected into the hand, wrist, or arm using a hypodermic needle in the same way as a vaccine [5]. In some cases it has been implanted in the hand in order to open the door of an office, make payments or block the telephone [1,4,6]. The possibility of using microchips implanted in the brain to control prosthetic limbs has also been indicated [5]. It is also posssible to use microchips inside pills to be ingested orally and used to evaluate the health

of a person. The Data is sent to a phone and from there it is transmitted to your doctor [5]. It is also known that it can cause privacy problems for the patient if it contains medical information [1,5,7].

In nursing homes and hospitals, the loss of complete prostheses is an important factor [8,9]. Previous authors describe the loss of 695 dentures in Surrey and Sussex hospitals between 2011-16 [10]. In a study carried out with older people, after the great earthquake in East Japan in March 2011, it was found that 17.2% had lost their dentures and this had caused them difficulties in eating, speaking, smiling and social integration [11]. Many authors indicate that prostheses have to be marked to avoid their loss [12-15]. This identification is used for forensic purposes to identify possible victims of violent deaths, massacres, terrorist attacks, tsunami, or cremation of bodies [12,14,16,17]. There is no international consensus regarding the obligation or not to mark dental prostheses and it depends on each country [15]. In Sweden they use a metallic marking band embedded in the acrylic. That contains a personal number, combining date of birth and gender [15]. Other information such as the patient's initials and date of birth, a telephone, the abbreviation of the dental clinic, the file number or even the driver's license number could be used too [18]. The manufacturer of dental prostheses Nobilium offers a system of identification of dentures that uses a chip with frequencies of 13.56 Mhz. Each chip should have a coded identification number linked to the identification of the patient, their dentist and the date of placement. The chip can be read with a specific reader connected to a computer through a USB port or with a smartphone [9]. The possibility of RFID microchips implanted in human molars using resin composites [19,20] and also implanting them in dental prostheses [4] has been suggested. Even the maximum occlusal load on the implant in the tooth has been studied, as well as the temperature at which the RFID microchip can fail [21-23].

The objective of this work is to study the possibility of using a coded personal identification microchip under a dental filling, under a metal-porcelain crown or in a dental prosthesis, for forensic purposes.

MATERIALS AND METHODS

In various databases (Medline, Scielo) and in Internet search engines, a bibliographic review of scientific works has been carried out on labels and marks used in human or animal forensic identification. Those articles considered of greatest interest for this work have been selected. The material used has consisted of:

2.1. Programmable adhesive RFID tags:

5 * 5mm Micro FPC NFC Ntag213 with 1mm reading range that have an NTAG213 chip (Fig.1), which is compatible with Mifare Ultralight (brand of chips used in contactless smart cards and proximity cards).

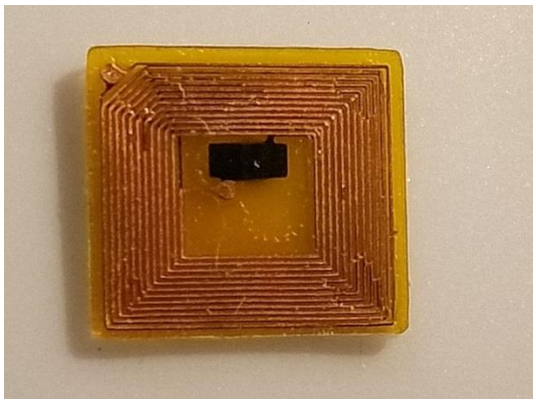

Fig.1: RFID tag used in this study.

This tag has 144 bytes of memory (7 bytes are of chip data identification, 131 bytes of information for writing characters and another 6 in relation to the storage structure of those 131 bytes). In those 131 characters we could include: country, collegiate number, medical history, ID, name, date of birth of the patient, sex, Social Security number. Those 131 characters are equivalent in the case of Spain to:

ES;Medico********;Historial********;DNI*********;Nombre:**********;FechaNac********;Sexo*;Seg.Social**********

2.2. Proxmark 3 Easy:

to read and write the RFID tag (https://proxmark.com/proxmark-3-hardware/proxmark-3-easy) (Fig.2). This reader is programmable and we use the RfidResearchGroup / Proxmark software (https://github.com/RfidResearchGroup/proxmark3) for a Linux operating system, although there are versions for Windows.

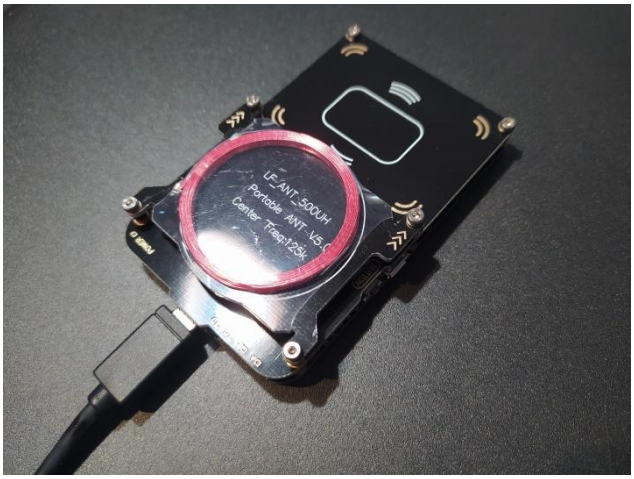

Fig.2: Image of Proxmark 3 Easy.

2.3. Two natural human teeth (upper right canine and lower left molar) embedded in plaster:

Heliobond Ivoclar Vivadent adhesive, Ventura Flow composite, Ventura Similux composite and Tetrix Color Vivadent were used to cover the RFID tag on the molar and canine (Fig.3).

Fig.3: Canine and molar where the RFID tag has been embedded and covered with composite.

2.4. A plaster lower jaw model with an RFID tag under a metal-porcelain crown (Fig.4).

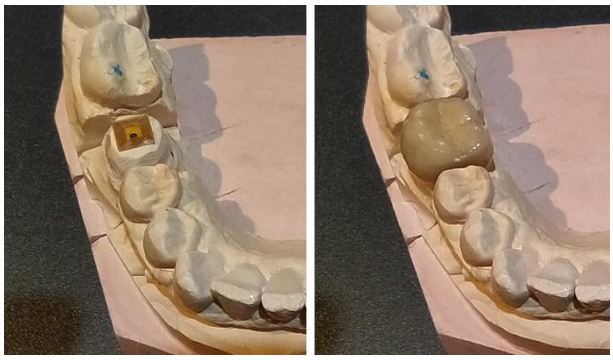

Fig.4: RFID tag located under a metal-porcelain crown.

2.5. Acrylic resin prosthesis:

with an identifying mark on which there are initials of the patient´s name and with an RFID tag embedded inside (Fig.5).

Fig.5: Dental prosthesis with an identifying mark (A) and other one with an RFID tag (B).

RESULTS

3.1. The methods to identify a dental prosthesis, according to the bibliography consulted, are in table1.

Table.1: Summary of denture identification methods [4,16,24,25].

Methods collected in the revised bibliography	On the surface of the prosthesis	-Engraving -Painted -Barcode
	Inclusion within the prosthesis	-Identification marks -Lenticular card -Barcode -Radio frequency -Photographs -Data Matrix Code -Microlabels -Memory card
	Out of prosthesis	-Marked boxes

		-Dental prosthesis-dental floss-clothing attachment with safety pin

3.2. The common data of the RFID tag are in table 2.

Table.2: A characteristic of the RFID tag is a physical memory size of 144 bytes.

```
[=] --- NDEF Message
[+] Capability Container: E1 10 12 00
[+]   E1: NDEF Magic Number
[+]   10: version 0.1 supported by tag
[+]       : Read access granted without any security / Write access granted without any security
[+]   12: Physical Memory Size: 144 bytes
[+]   12: NDEF Memory Size: 144 bytes
[+]   Additional feature information
[+]   00
[+]   00000000
[+]   xxx      - 00: RFU (ok)
[+]      x     - 00: don't support special frame
[+]       x    - 00: don't support lock block
[+]        xx  - 00: RFU (ok)
[+]          x - 00: IC don't support multiple block reads
[=] Tag reported size vs NDEF reported size mismatch. Using smallest value
```

3.3. The RFID tag empty of data gives us a reading according to table 3.

Table.3: Reading the RFID tag that is empty of data.

```
 [+] --- NDEF Message ---
[+] Found NDEF message w zero length
[=] ------------------------------------------------------
[+] NDEF Terminator detected
```

3.4. The reading of the RFID tag with data, located on the teeth under the fillings or on the acrylic resin prosthesis are in table 4.

Table.4: Reading of the RFID tag with data, on the teeth or on the acrylic resin prosthesis.

```
[+] --- NDEF Message ---
[+] Found NDEF message (137 bytes)
[+] Record 1
[=] ------------------------------------------------------
[=] Header:
[+]       Message Begin:    +
[+]       Message End:      +
[+]       Chunk Flag:       -
[+]       Short Record Bit: +
[+]       ID Len Present:   -
[+]       Type Name Format: [0x01] Well Known Record
[+]       Header length    : 3
[+]       Type length      : 1
[+]       Payload length   : 133
[+]       ID length        : 0
[+]       Record length    : 137
[=] Type data:
00: 54                                |T
[=] Payload data:
```

```
00: 02 65 6e 45 53 3b 4d 65 64 69 63 6f 2a 2a 2a 2a |.enES;Medico****
10: 2a 2a 2a 2a 3b 48 69 73 74 6f 72 69 61 6c 2a 2a |****;Historial**
20: 2a 2a 2a 2a 2a 2a 3b 44 4e 49 2a 2a 2a 2a 2a 2a |******;DNI******
30: 2a 2a 2a 3b 4e 6f 6d 62 72 65 3a 2a 2a 2a 2a 2a |***;Nombre:*****
40: 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a 2a |****************
50: 2a 2a 2a 2a 2a 2a 3b 46 65 63 68 61 4e 61 63 2a |******;FechaNac*
60: 2a 2a 2a 2a 2a 2a 2a 3b 53 65 78 6f 2a 3b 53 65 |*******;Sexo*;Se
70: 67 53 6f 63 69 61 6c 2a 2a 2a 2a 2a 2a 2a 2a 2a |gSocial*********
80: 2a 2a 2a 2a 2a                                  |*****
[=] Well Known Record
[=]       type      : T
[=]       UTF 8     : en,
ES;Medico********;Historial********;DNI*********;Nombre:**********
**********;FechaNac********;Sexo*;SegSocial**************
```

3.5. Reading the RFID tag with data, located under the metal-porcelain Crown.

it does not give any type of result.

DISCUSSION

The RFID tag can be used to identify patients and to access their clinical information [1], but they have several drawbacks. When introduced into the human body, it can cause swelling and hematoma [3], granuloma due to foreign body reaction, encapsulation and cancer in the implant area (sarcomas and fibrosarcomas), but the latter is not confirmed [1,2,16] . When the microchip is implanted in the tooth, this type of injury is unlikely, since in dentistry there are many years of experience using different materials to restore it, including silver amalgams. In general, several laws have prohibited the mandatory RFID tag, however whether a person does it voluntarily remains a matter of controversy [1]. There are also problems with reading the microchip, as not all scanners are capable of reading them. This may be due to lack of compatibility, patent protection, or simple commercial interests [3].

However, there are instruments such as the Proxmark that is versatile and can be used to read any RFID tag. The unauthorized reading of microchips can present a risk to privacy, for this reason the information would have to be encrypted [2,3,7]. But this is not applicable to this type of microchip because it has little memory capacity. To write the information on the microchip, the encoding goes from ASCII to hexadecimal format and from this to binary, and that is how the information is stored in the chip. The reverse process is followed to read the information. Sometimes it conflicts with the legislation of the country where it is used [7]. However it can be useful in certain professions such as being a soldier, to identify their remains if they die in battle [5]. We agree with other authors that a prosthesis is an important element for the forensic identification of people, in the event of massive disasters [15,17,26], but the prosthesis can be lost. The use of microchips located in teeth under resin dental restorations has already been described [2,16,19]. They could be more useful in the identification of people than removable prostheses, since they are attached to the tooth. According to the authors, the dimensions of the microchips are large and require a large cavity, but biomechanically it is possible to implant a microchip in a Class V cavity using resin-based restorative material for forensic human identification purposes [20]. However, the identification mark has difficulties to resist fire. There are authors who placed a titanium plate in 10 sample molars and the mark and filling material only resisted up to 800ºC [22]. Other authors placed a passive RFID microchip in 10 molars during composite restorations and they only resisted up to 300ºC without damaged [23].

None of the described marking methods are used for forensic identification purposes in all cases, since high temperatures they are damaged [21]. The methods of marking surfaces and that of inclusion in prostheses have an added cost for the prosthetic laboratory and do not prevent the loss of the prosthesis.

The chip runs at 13.56 MHz, so it is considered high frequency. In this way most smartphones could read it. However the chip is very small and a smartphone won't detect it. It needs something more powerful like it is the Proxmark. The most recent version that we can use is RDV4.01 (https://proxmark.com/proxmark-3-hardware/proxmark-3-rdv4). A PN532 Arduino module could also be used for reading, but it is not designed for this use, so it is not efficient. When this high-frequency microchip is placed under a metal-porcelain crown, we do not get any responde in the Reading. This may be because the material used prevents the transmission of the stored information to the reader. In this case a low-frequency microchip could be used to store a unique identifier in relation to a database.

CONCLUSION

The RFID tag located under a filling in a tooth or embedded in an acrylic resin prosthesis is useful for storing coded personal information and this is of great forensic interest. There are limitations when using this microchip in humans due to lack of privacy of their personal data and adequate legislation is necessary for its use.

Conflict of interests: the authors declare no conflict of interest.

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