

## Revista Brasileira de Odontologia Legal – RBOL

ISSN 2359-3466

<http://www.portalabol.com.br/rbol>



### Forensic Odontology

#### USE OF QR CODE AS PERSONAL IDENTIFICATION OF COMPLETE DENTURES – LITERATURE REVIEW.

##### *Uso do código QR como identificação pessoal de próteses totais - revisão de literatura.*

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#### Information about manuscript

Received : 19 Oct 2017

Accepted: 30 Nov 2017

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#### ABSTRACT

Different methods for identification of complete dentures have been described as well as the importance of its use. Recently, the QR code has been highlighted as a simple and effective novelty for this purpose, but its use in daily clinical practice is still poorly reported. The aim of this study was to perform a literature review regarding the use of the QR code in complete dentures as a system of personal identification of denture wearers. An electronic search was performed in the Pubmed database in June 2017. A specific search strategy was developed and executed, considering as inclusion criteria studies published in the last 10 years. After selecting and reading titles and abstracts, 8 studies were included in the final list. The use of the QR code in complete dentures has been described as simple, efficient and capable of storing a considerable amount of information. Some laboratory studies have tested the resistance of the QR code covered by acrylic resin against adverse conditions such as heat, chemicals and fractures, which, in general, confirmed the feasibility of using this identification alternative. It is important to point out the need for dissemination among dentistry students and patients regarding the benefits and legal importance of having a complete denture identification system.

#### KEYWORDS

Complete denture; Denture identification marking; Forensic dentistry; Forensic sciences.

#### INTRODUCTION

Forensic Dentistry has participated frequently in the identification of bodies by comparing dental records before and after death. In dentate individuals, the anatomical,

pathological and therapeutic characteristics may constitute potential points of specificity that can be considered during the process of human identification. However, when edentulous individuals require identification

their complete dentures become important sources of information<sup>1</sup>.

Complete dentures can be useful as a tool for forensic identification in cases of natural disasters such as earthquakes, landslides, floods, fires and air accidents<sup>2-4</sup>. In addition, with the aging population and the increase in the number of hospitalized elderly and nursing homes, the importance of dentures has been highlighted as a way of identifying these individuals<sup>4</sup>. Similarly, identification through dentures has great value for patients presenting neurodegenerative disorders, such as Alzheimer's and Parkinson's disease, or other conditions that affect memory and reasoning<sup>3-5</sup>.

In the literature, several denture marking techniques are described and didactically divided into surface methods and inclusion methods<sup>6</sup>. Surface methods consist of marking the denture by means of writing or embossing, which despite being less costly may result in problems such as plaque buildup, mucosal irritation, and discomfort<sup>7,8</sup>. In addition, these methods do not provide a permanent identification and require frequent remarks<sup>4</sup>. On the other hand, inclusion methods consist in the incorporation of a marker, such as photography, electronic microchip, stainless steel, lenticular system, barcode, among others, which vary widely in relation to the inclusion technique and reading<sup>8,9</sup>.

Recently, the QR code has been highlighted as a simple and effective alternative for this purpose. It is a two-dimensional barcode type, also called 2D code, matrix code or QRC (*quick response code*) and it is capable to store a

considerable amount of data than just the personal information, such as a brief history of the patient's medical or dental history. In addition to the bigger data storage capacity when compared to one-dimensional barcodes, the QR code can be read through smartphones that contain a QR code reading app, usually available for free download in the virtual app stores<sup>6</sup>. Despite the widespread use of the QR code for other purposes, its implementation in dental practice for purposes of personal identification of edentulous individuals by its inclusion in complete dentures is still poorly reported, especially in the Brazilian scenario.

Thus, the aim of this study was to perform a literature review regarding the use of the QR code as a system of personal identification of complete dentures.

## LITERATURE REVIEW

### **Search protocol and study selection**

This literature review included studies concerning the use of the QR code as a form of personal identification of complete dentures. The search was conducted in the PubMed database and the last literature search was performed in June 2017. We considered articles published in the last 10 years and no language restriction was considered for this review. Specific terms related to the topic and Boolean operators were combined resulting in the following search strategy: (Denture identification marking[MeSH Terms]) OR QR code[Title/Abstract] OR bar cod\*[Title/Abstract] OR matrix cod\*[Title/Abstract] OR quick response cod\*[Title/Abstract] OR denture barcod\*[Title/Abstract]) AND (((complete

denture[MeSH Terms]) OR dentures[MeSH Terms]) OR denture\*[Title/Abstract]) OR prosthesis[Title/Abstract]). To be included in this review, the publication must report any aspect related to the use of the QR code in complete dentures. Publications reporting marking techniques different from the QR code or the use of QR code in other types of dental prosthesis were excluded.

The electronic search resulted in 26 publications. After reading the titles and

abstracts, 7 studies were considered for inclusion in the preliminary list. Moreover, a manual search was performed in the references of these publications and 1 additional study was retrieved, resulting in 8 studies in the final list of this review. The following information was extracted from the full-text versions of the included articles and are presented in Table 1: study type, year of publication, corresponding author's country and main objectives.

Table 1. Characteristics of the included studies.

| Type of study     | Authors/Year                                     | Corresponding author's country | Study Aim  |
|-------------------|--|--------------------------------|--|
| Authors' comments | Fonseca & Cantín, 2015 <sup>17</sup>             | Argentina and Chile            | Critical analysis of the paper by Ragavendra <i>et al.</i> , 2014 <sup>1</sup> .   |
| Laboratory study  | Ragavendra <i>et al.</i> , 2014 <sup>1</sup>     | India                          | To assess the effect of three types of acids (sulfuric, nitric and hydrochloric) in QR codes included in conventional complete dentures. |
| Laboratory study  | Poovannan <i>et al.</i> , 2016 <sup>13</sup>     | India                          | To test the resistance of QR codes to fracture, high temperatures and contact with acids.  |
| Case report       | Rajendran <i>et al.</i> , 2012 <sup>10</sup>     | India                          | To describe a technique for incorporating the QR code in a conventional denture.   |
| Case report       | Sudheendra <i>et al.</i> , 2013 <sup>6</sup>     | India                          | To describe a technique for incorporating the QR code in a conventional denture.   |
| Case report       | Dineshshankar <i>et al.</i> , 2015 <sup>11</sup> | India                          | To describe a technique for incorporating the QR code in a conventional denture.   |
| Case report       | Jain <i>et al.</i> , 2015 <sup>12</sup>          | India                          | To describe a technique for incorporating the QR code in a conventional denture.   |
| Case report       | Basavanna <i>et al.</i> , 2016 <sup>5</sup>      | India                          | To describe a technique to incorporate the QR code into the denture of a patient with Parkinson's disease.                               |

### **Production and incorporation of the QR code in complete dentures**

In general, the techniques reported in the literature regarding the incorporation of the QR code into complete dentures involve the following sequence: (a) inclusion of patient information in a QR code generator; (b) production and impression of the QR code on paper; (c) cutting of the code and waterproofing using laminated paper or similar materials; (d) production of a recess in the denture with compatible dimensions with the code and in flat regions like the palate in the maxillary denture and the external lingual flange in the mandibular denture; (e) positioning of the code in the denture and coverage with the use of self-curing acrylic resin; (f) removal of excess, finishing and polishing; (g) download the QR code reading app on smartphone or other compatible devices and code reading-test<sup>5,10,11</sup>.

Some variations were observed with respect to the way of obtaining the code. Rajendran *et al.* (2010)<sup>10</sup>, Dineshshankar *et al.* (2015)<sup>11</sup> and Basavanna *et al.* (2016)<sup>5</sup> reported the use of the software *QR 2 Kaywa-Code Generator* (Kaywa AG, Zuriq, Suíça) and Sudheendra *et al.* (2012)<sup>6</sup> reported the use of the software *Barcode Generator*. In a different way, Jain *et al.* (2015)<sup>12</sup> suggested the use of the website [www.the-qrcode-generator.com](http://www.the-qrcode-generator.com) as an alternative to obtain the QR code without the need to install a software.

In addition, different QR code decoding apps have also been described among studies. The mobile app *I-nigma* (v3.10.02, 3GVision, Yehuda) was used in the studies of Rajendran *et al.* (2010)<sup>10</sup>,

Dineshshankar *et al.* (2015)<sup>11</sup> and Basavanna *et al.* (2016)<sup>5</sup>. Other studies did not describe which specific app was used and there was only a mention that a QR code decoder obtained free of charge in the app stores was employed.

The incorporation of the QR code was another aspect that presented different conducts among the studies. In general, it was reported that the QR code was laminated after being printed and cut, which means that it was wrapped with a layer of laminated paper and then incorporated into the denture by means of a self-curing acrylic resin cover<sup>5,6,10,11</sup>. However, Jain *et al.* (2015)<sup>12</sup> presented a new technique using a 1mm thick prefabricated acrylic sheet, which was placed above the already laminated QR code and positioned in the prosthesis, and then the edges of the lamina were fused to the prosthesis by means of self-curing acrylic resin.

### **Resistance and durability of the QR code**

In addition to the case reports mentioned above concerning the technique of obtaining and incorporating the QR code in complete dentures, some studies have investigated the resistance and durability of the QR code through laboratory tests against different physicochemical conditions.

Ragavendra *et al.* (2014)<sup>1</sup> assessed the durability of QR codes included in complete dentures when exposed to acid solutions. Fifteen dentures were individually immersed in flasks containing sulfuric acid (n=5), nitric acid (n=5) and hydrochloric acid (n=5). At each 1-hour interval, the viability of reading the QR code was verified through a smartphone. The code remained viable for a

longer period when immersed in hydrochloric acid (mean 31.6 hours), followed by sulfuric acid (mean 15.8 hours) and nitric acid (mean 14.4 hours). The authors emphasized that an improvement in the heat resistance and acid resistance can consolidate the use of the QR code as a standard personal identification system for dentures, thus providing a cheap, reliable and long-lasting alternative.

Sudheendra *et al.* (2012)<sup>6</sup> reported durability tests of a set of total dentures labeled with QR code. The tests consisted of immersion of the denture in water for 10 days; autoclave exposure at 121°C for a 15-minute cycle and direct flame test. The code remained intact and readable after these procedures.

In another study, Poovannan *et al.* (2016)<sup>13</sup> assessed the reliability of the QR code incorporated in different depths of acrylic resin blocks and exposed to acids, heat, and fractures. In this laboratory study, 160 acrylic resin blocks were divided into 4 groups according to the depth of incorporation of the code: 1, 2, 3 or 4mm. For the acid exposure test, samples were immersed in 99% sulfuric acid and 40% hydrochloric acid for one hour. In the thermal test, the blocks were heated in a furnace at 500°C and in the fracture test the blocks were fractured at the center in an Universal Testing Machine. The reading of the QR code was possible in all depths, as well as after immersion in both acids for the period of one hour. Regarding the thermal test, the reading was only possible up to 370°C and the codes burned when the temperature approached 500°C. The reliability of reading was variable in relation to the fracture test

and it depended on the level of distortion generated after the occurrence of the fracture. The authors concluded that the QR code is a reliable identification system considering different depths of incorporation of the code in the acrylic resin, acid exposure and temperature up to 370°C.

## DISCUSSION

Considering the currently available scientific evidence, the use of the QR code as a method of identification in complete dentures presents several relevant advantages in comparison to other methods and is well accepted by the patients. Some authors point that an ideal denture identification system should present characteristics such as low cost and easy execution; ability to provide patients' personal data in any situation; no influence in the structure, adaptation and esthetics of the denture; resistance to high temperatures and fire<sup>2-4,6,14</sup>. In addition, regardless of the material used, it cannot compromise the use of the denture and the patients' daily routine. The use of the QR code complies with the majority of these requirements and there is only a limitation related to resistance to high temperatures, as reported by Poovannan *et al.* (2016)<sup>13</sup>, who concluded that the QR code reading was only viable up to 370°C and the codes burned when exposed near 500°C.

The authors also emphasized the best location for the incorporation of the QR code in order to facilitate reading and preventing from any kind of functional or aesthetic discomfort to the patient. In the maxillary denture, it is recommended that the device should be installed on the palatal

surface or in the buccal region of the maxillary tuberosity. For the mandibular denture, the posterior distolingual flange must be chosen<sup>3,5,7</sup>.

It is important to mention that the use of an identification marker in dental prostheses is a mandatory procedure regulated by legislation in some countries and most international dental associations and forensic dentists recommend it<sup>5</sup>. In 1979, the American Dental Association stated a dental labeling law recommending the use of uniform methods of marking dental prosthesis for forensic identification purposes<sup>15</sup>. Besides the dissemination of this recommendation worldwide, the denture labelling law is followed by few countries in the world, such as Sweden, Scotland, United Kingdom, 21 states in the United States, and Australia<sup>16</sup>. Some regulations impose marking only for long-term hospitalized patients and for army officers<sup>4</sup>. In this context, it is recommended that in addition to informing and encouraging the patient about the importance of the identification, the dentist must obtain the patient informed consent or from his legal guardian before incorporating the identification system into the denture, which may prevent some legal issues<sup>11</sup>.

## RESUMO

Diferentes métodos de identificação de prótese total têm sido descritos na literatura científica, bem como a importância de sua utilização. O código QR (QR code) tem sido destacado recentemente como uma novidade simples e efetiva para este fim, porém seu uso na prática clínica diária ainda é pouco relatado. O objetivo deste estudo foi realizar uma revisão de literatura a respeito do uso do código QR como sistema de identificação pessoal de usuários de próteses totais. Foi realizada uma busca eletrônica na base Pubmed em junho de 2017. Uma estratégia de busca específica foi elaborada e executada, considerando-se como critério de inclusão estudos publicados nos últimos 10 anos. Após seleção e leitura dos títulos e resumos, 8 estudos foram incluídos na lista final. O uso do código QR em próteses totais é descrito como um método de identificação simples, eficaz e capaz de armazenar uma quantidade considerável de informações. Alguns estudos laboratoriais testaram a resistência do código QR coberto por resina acrílica frente a condições adversas como calor, substâncias químicas e fraturas os quais, em geral, confirmaram a viabilidade de uso desta alternativa de identificação. Ressalta-se a necessidade da

Despite the clear and evident importance already mentioned, the lack of awareness, information, and belief of little importance limits the dissemination and the use of identification methods of complete dentures in the dental routine. It is strongly recommended the inclusion and reinforcement of this topic in the dental education as an integral part of the clinical sequence of making complete dentures and also in disciplines that deal with forensic dentistry. The simplicity of using the QR code can enable anyone with a smartphone to access patient information in situations that are necessary and a single positive identification by itself justifies in some way the use of this system<sup>11</sup>.

## FINAL CONSIDERATIONS

The use of the QR code as a method of personal identification in complete dentures presents most of the requirements recommended in the literature for a method of human identification, except for the resistance to high temperatures.

It is important to point out the need for dissemination among dentistry students, dentists, and patients regarding the benefits and legal importance of implementing a system of identification in complete dentures.

divulgação entre estudantes de Odontologia e pacientes a respeito dos benefícios e importância legal em haver um sistema de identificação em próteses totais.

## PALAVRAS-CHAVE

Ciências forenses; Identificação da prótese dentária; Prótese total; Odontologia forense.

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