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Detecting the manipulation of digital clinical records in dental practice

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ABSTRACT

Introduction: Radiography provides many advantages in the diagnosis and management of dental conditions. However, dental X-ray images may be subject to manipulation with malicious intent using easily accessible computer software.
Methods: In this study, we sought to evaluate a dentist's ability to identify a manipulated dental X-ray images, when compared with the original, using a variant of the methodology described by Visser and Kruger. Sixty-six dentists were invited to participate and evaluate 20 intraoral dental X-ray images, 10 originals and 10 modified, manipulated using Adobe Photoshop to simulate fillings, root canal treatments, etc.
Results: Participating dentists were correct in identifying the manipulated image in 56% of cases, 6% higher than by chance and 10% more than in the study by Visser and Kruger.
Conclusion: Malicious changes to dental X-ray images may go unnoticed even by experienced dentists. Professionals must be aware of the legal consequences of such changes. A system of detection/validation should be created for radiographic images.

Introduction

Since 1982, when Mouyen[1] introduced the first digital system for dental radiography, images acquired with this technique have improved in terms of quality and the resultant radiation dose to the patient.

Digital radiography presents several advantages, such as the ease of storage of the image, no loss of quality with time, elimination of film processing and the associated need for a waste removal service and the purchasing of chemicals. Digital acquisitions allow the creation of multiple copies of the X-ray image and it allows some visual parameters to be improved through computer manipulation of the image.[2]

Along with these advantages software has been developed which allows the photographic retouching of images. This allows anyone with a computer and an image modification program to be potentially able to modify a dental X-ray image and completely vary its original appearance according to their requirements.

Taking into account that any dental X-ray image exported as an image file can be susceptible to image manipulation, this manipulation can divided into two categories:

- Non-malicious: it helps make the image more visible to the human eye and is designed to assist the reader,
- Malicious: data are added to or removed from the original image with a view to misleading the reader.

Image manipulation generates a problem of legal security since there is no control over the manipulation of the dental X-ray image in the event of a potential legal claim over treatment.

If the patient or dentist does not have access to a previous conventional radiography (non-digital) then it may be difficult to validate a failed treatment presented on digital media. This is because the possibility manipulation is unknown and currently there are no standardized systems available for the verification of radiographic images.

Attempts to standardize safety protocols have been reported within the literature, but have not yet been implemented in clinical practice.[3,4] This may be due to logistical difficulties but it has also been highlighted the ease in which an image can be modified, often without a dental professional. Detection of such manipulations is also difficult, as shown in the study by Visser and Kruger,[5] who

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observed that in most cases dentists were unable recognize the modified images. Likewise, Tsang,[6] with a more crude system, based on conventional scanned radiographs, managed to make insurance companies believe that teeth which had been treated with simple fillings had in fact undergone complex endodontic treatment with intraradicular posts and crowns.

It is necessary, therefore, to create a validation system for digital radiographic images which is simple use and that can be implemented without problems into routine clinical practice.

The aim of this study was to evaluate a dentist's ability to identify a manipulated dental X-ray image when compared with the original using a variant of the methodology reported by Visser and Kruger.[5]

Materials and methods

Sixty-six practicing dentists were selected, all with professional experience ranging from 2 to 20 years. No criteria were applied in terms of gender, age or knowledge of computers, thereby following the participant selection process described by Visser and Kruger.[5] The following changes to Visser and Kruger's methodology were also made:

- The number of participants was increased from 39 to 66.
- Ten pairs of dental X-ray images were given out, one original and one manipulated, thereby allowing the participants to compare the two.
- Participants in the study had no time limit for the evaluations and were not provided with any tools to assist in the identification of the manipulated image.
- Participating dentists received e-mail messages containing 20 paired dental X-ray images, 10 originals and 10 modified (on the basis of the originals) (Figs. 1–5).

All of the dental X-ray images were obtained from personal clinical records of the research team, having been taken using the following digital imaging equipment: GXS-700® (Gendex®) and VistaScan Mini® (Dürr Dental®).

All dental X-ray images were saved as a JPG file (Joint Photographic Experts Group) so that the original image could be modified using Adobe Photoshop CS6 software®. The modifications that were carried out consisted of adding bone to radiolucent areas, placing restorations in unfilled teeth or putting in place radiopaque materials which simulated root canal treatments. Identification of each dental X-ray image was subject to a coding process in order to maintain anonymity. Each dental X-ray image was assigned an identification code which complied with the ethical approval for the study.

Once participants had received the image bank they were permitted to use all of the tools they thought necessary to identify the real image. Decision were recorded in a table prepared using Google Docs (Google Inc.®) and all participants remained blind to one an others classifications.

Statistical analysis

To determine the general percentage of correct answers and the probabilities determined by chance, the Binomial test was used as a test of deviations from a theoretically predicted distribution of observations in two categories. This approach was similar to the data analysis reported in the study by Visser and Kruger.[5]

Results

Using the Binomial coefficient or combinatorial number, the probabilities determined by chance were calculated (Table 1) for all

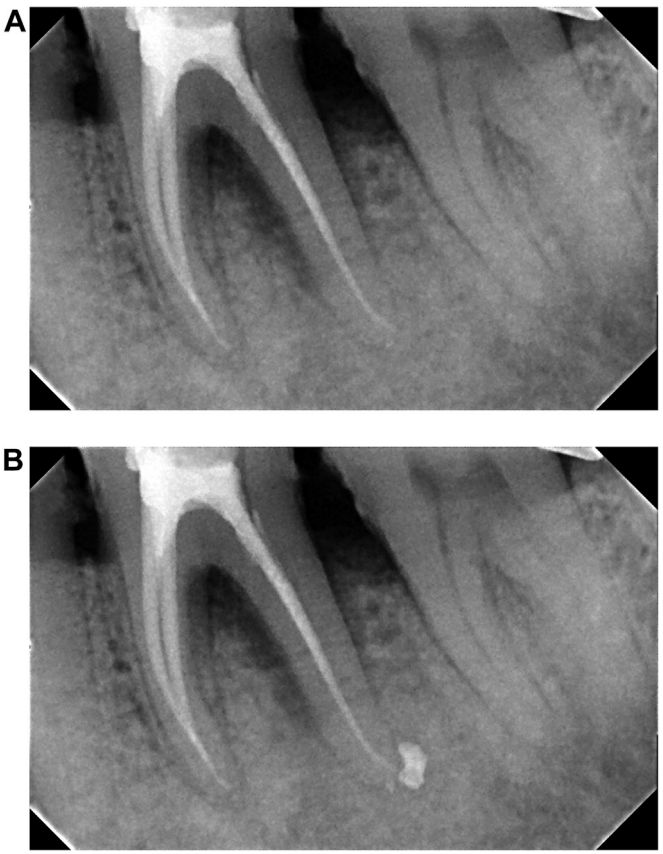

Figure 1. A. Sample image: non-manipulated. B. Sample image: manipulated, extrusion of dental cement to periapex added.

of the possible events in the sample space, or, the probability of selecting the correct type of radiograph (non-manipulated/manipulated) zero, one, two times, etc. Likewise, the probability was calculated in our experiment for each of the events, using the Frequency Sampling or Objectivist Method or Bayesian Method that links the probability of A given B with the probability of B given A, or the probability of causal aspects given the observed effects (Table 2).

In order to determine the general percentage of correct answers (P), bearing in mind the independent nature of the events, the number of favorable cases (correct answers) was divided by the number of possible cases, giving an overall result of correct answers equal to 56%.

$$P = \frac{Correct\ answers}{All\ cases} = \frac{371}{660} = 0.56 = 56$$

The study is made up of a series of Bernoulli experiments, and therefore the Binomial distribution can be used to make predictions.

$$\chi \sim B(n, p) \text{ in which } p = 0.56$$

In the results by radiograph, the breakdown of correct/incorrect answers was generally homogeneous, reaching close to 50%. It was found that in 3 of the 10 pairs of radiographs which were analyzed, the percentage of incorrect answers was greater than the number of correct answers, and that the radiograph for which the correct option was selected most often did so among just 78% of the participants.

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