

Digital Radiographic Image Processing: Science or Fraud?

Dijital Radyografik Görüntü İşleme: Bilim ya da Aldatmaca ?

Pelin GÜRDAL B. Güniz AKDENİZ

Ege Üniversitesi, Dişhekimliği Fakültesi, Oral Diağnoz ve Radyoloji AD, İzmir

Abstract

Objectives: With the advent of digital imaging, computed radiographic images are now available in dental clinics. However, these images can be easily altered even with personal computers, by application of image processing software. This paper aims to demonstrate the examples of such image reconstructions, discusses the potential problems arising with the use of image processing softwares, and presents methods to prevent such fraudulent use of digital radiographs.

Materials and Methods: Five periapical and one orthopantomographic films were obtained by routine radiographic measures, and were scanned. A software was used to alter the digital images, and carious lesions, periapical pathoses, fractures were created in sound teeth or alveolar bone, whereas inadequate treatment were corrected, or teeth were erased from the images to simulate extracted teeth.

Results and Conclusion: This study revealed that digitized radiographic images can be altered by application of a software, and precautions necessary to preclude this type of use of software programs shall be practiced. In order to provide authenticity of digital data, embedded encryption, error correction-code memory, and digital watermarks are added to the software programs.

Keywords: Digital radiographic images, image processing

Özet

Amaç: Dijital görüntüleme alanındaki gelişmelerin sonucu olarak, günümüzde kompüterize radyografik görüntüler dental kliniklerde kullanılmaya başlanmıştır. Ancak bu görüntüler, görüntü işleme programları kullanılarak kişisel bilgisayarlarda bile değiştirilebilmektedir. Sunulan çalışmada bu tür yeniden oluşturulmuş görüntülerden örnekler verilerek, görüntü işleme programlarının kullanılmasıyla ortaya çıkabilecek potansiyel sorunların tartışılması ve dijital radyografilerin bu tür bilimsel etiğe aykırı kullanımını engelleyecek yöntemlerin sergilenmesi amaçlanmaktadır.

Gereç-Yöntem: Beş periapikal ve bir ortopantomografik film, rutin radyolojik yöntem ve ekipmanlar kullanılarak elde edildikten sonra tarayıcıdan geçirilmiştir. Dijital görüntüleri değiştirmek amacıyla bir bilgisayar programı kullanılarak, sağlıklı dişlerde ve alveol kemiğinde çürük lezyonları, periapikal patolojiler, kırıklar oluşturulmuştur. Yanısıra, yetersiz tedaviler düzeltilmiş, ya da diş çekilmiş görüntüsü oluşturmak üzere, dişler görüntülerden silinmiştir.

Bulgular ve Sonuçlar: Sunulan çalışma, dijitiye radyografik görüntülerin bir bilgisayar programı ile değiştirilebileceğini ve programların bu tür kullanımını engellemek amacıyla gerekli önlemlerin alınmasının önemini ortaya koymuştur. Dijital verilerin orijinalliğini sağlamak amacıyla bilgisayar programlarına çeşitli koruyucu yöntemler eklenmeye başlanmıştır.

Anahtar sözcükler: Dijital radyografik görüntüler, görüntü işleme

With developments in dental imaging, dental researchers are able to assess and evaluate the changes in alveolar bone more precisely, to detect peri-implant bone healing, and to improve caries

detection.¹⁻⁶ It is known that digital imaging has several potential advantages over the conventional methods, such as instantaneous availability of radiographs,⁷⁻¹⁰ patient education,^B elimination of

developing chemicals and equipment,⁹⁻¹⁰ storage of the images indefinitely,^{10,13,14} reduced exposure to radiation for patients,¹⁰⁻¹⁴ and enhancement of images.¹⁰⁻¹⁴

However, the ease of using the image enhancement facility of digital radiology also prones the system to mishandling or potential abuse.¹⁵ It has been reported that by using numerous software packages created for production of graphics and manipulation of images, digital radiographic information can be altered, added or removed.¹⁶ In two recent studies investigating the potential fraudulent use of digital radiology, it has been concluded that unethical practitioners, although probably very few in number, may attempt to manipulate the radiographic images to provide evidence both for inadequate treatment, or of treatment which has not been performed at all.^{15,16}

Additionally, these findings provide enough support to alert the editors of the dental journals who are receiving numerous reports from various parts of the world to be evaluated for publication. If the images can be altered for authorization requests from the insurance companies as suggested by Tsang et al.,¹⁵ they can be easily modified to support the benefit of a particular medication, method or approach even when the truth is on the contrary, as well.

In this study, the applicability of image manipulation facility of a software program –which may be misused to threaten the accuracy or validity of digital radiographs– was investigated; and additionally, examples of the altered clinical images were presented.

Materials and Methods

Five periapical and one orthopantomographic digital images were obtained. First, the conventional radiographs were taken by using Kodak Ultra-Speed periapical films (58x76 mm, Eastman Kodak Co., Rochester, NY, USA), exposed at 70 kV and 10 mA for 0.64 second with a dental x-ray unit that had 2.5 mm of Al equivalent filtration (Trophy, Vincennes, France), and with a 40 cm film-target distance. The films were processed in fresh solutions (Hacettepe, Ankara, Turkey) in an automatic processor (Dürr XR

24, Germany) at 28°C for 4.3 min. Then, the films were digitized with a flatbed scanner (Umax Powerlook II, Umax Technologies, Inc. Taiwan) at 300 dpi and 8-bit resolution.

Panoramic film was taken with an orthopantomography (Planmeca, Instrumentarium, Finland) machine with total filtration equivalent to 2.5 mm of the aluminum thickness. Machine settings were between 68-80 kV and 165 mAs., and a Kodak Lanex medium screen film was used. Similar film processing and digitization processes were adopted for the panoramic film.

To alter the digital images, Adobe Photoshop 4.0 software program for PC (Adobe Corporation, San Jose, CA, USA) was used. Carious lesions, periapical pathoses, fractures were created in sound teeth or alveolar bone, whereas inadequate treatment were corrected, or teeth were erased from the images to simulate extracted teeth by application of various functions of the above mentioned software.

Original and altered digital radiographic images

Image 1

The original radiographic image displaying sound mandibular molar teeth were presented in the first figure (Fig. 1). Then, an apical lesion due to a profound distal caries in the mandibular first molar, and a mesial approximal caries in the mandibular second molar were created by using the airbrush function of the software (Fig. 2).

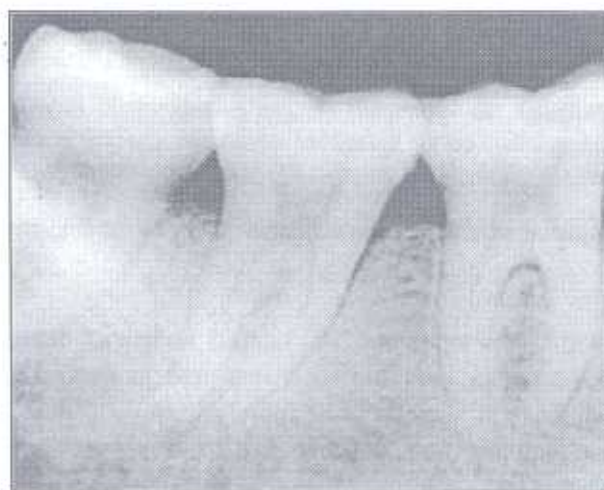


Fig. 1. Original radiographic image, revealing sound molar teeth.

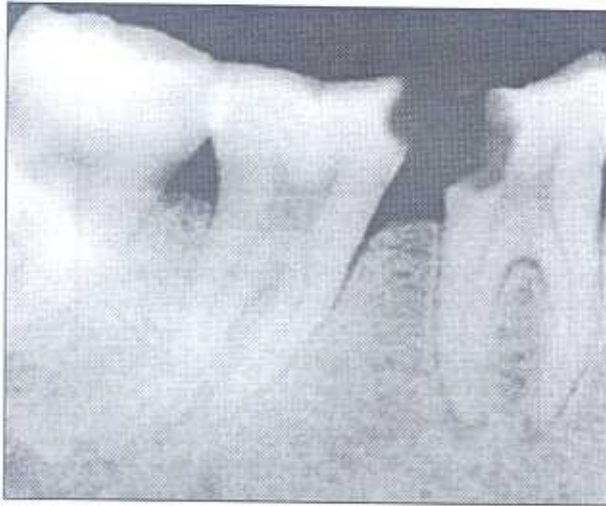


Fig. 2. Approximal caries and apical lesions created by application of the software.



Fig. 3. Original radiographic image, without any appearing pathologies.



Fig. 4. Recurrent caries lesions were designed on the image by using the software.

Image II

In another original radiograph, two amalgam fillings on mandibular first and second molar teeth were displayed (Fig. 3). After alteration of the image by using the airbrush function, two recurrent carious lesions on both mesial and distal approximal sides of the first molar, and under the distal part of the amalgam restoration on the second molar were designed (Fig. 4).

Image III

Mandibular left first molar had an inappropriate root canal filling, with a piece of broken instrument observed at the apex of the mesial root in Fig. 5. However, in the altered image, endodontic therapy was corrected with the help of the above-mentioned software (Fig. 6).



Fig. 5. Original radiographic image, showing an inappropriate endodontic treatment of the first molar tooth.



Fig. 6. The poor endodontic treatment has been corrected in the modified image.

Image IV

The original radiographic image of Fig. 1 was altered by graphics functions, and mandibular second molar tooth was 'extracted' from the image. Second molar tooth was selected and cut; then, normal alveolar bone appearance was created (Fig. 7).

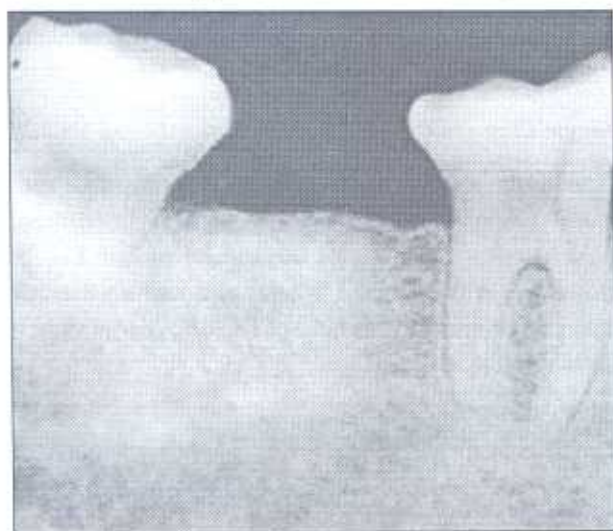


Fig. 7. The mandibular second molar in the original radiograph (Fig. 1) has been extracted by application of the software program.



Fig. 8. The original radiographic image of the maxillary left central incisor, revealing a root fracture at the apical third, and apparent alveolar bone loss in the area.



Fig. 9. The same image after correction by application of the facilities of the software program.

Image V

A coronal fracture at the middle third of the root of an incisor tooth was presented on an original radiographic image (Fig. 8). After using airbrush function of Adobe Photoshop 4.0, the fractured root was 'treated'. Also, interalveolar bone was 'healed' (Fig. 9).

Image VI

In Figure 10, the original image was presented with a normal appearing mandibular incisors, canine, and premolar teeth. However, in the altered image, lateral incisor tooth was 'extracted' and coronal part of the canine tooth was erased; then, a profound caries with an apical lesion was designed (Fig. 11).

Image VII

In a panoramic digital radiographic image, a random area was selected, without any alveolar bone pathosis (Fig. 12). After manipulation of the image with the software program, a fracture line was created (Fig. 13).



Fig. 10. The original radiograph of mandibular right canine area, revealing no dental or alveolar abnormalities.



Fig. 11. By using the software program, the coronal part of canine tooth was removed, and an apical lesion was added; also, the lateral incisor tooth was extracted.



Fig. 12. The original radiographic image, presenting mandibular left incisor-canine-premolar part of a panoramic film.



Fig. 13. The manipulated image of Fig. 12, revealing a fracture line between second premolar and second molar teeth.

Discussion

Even though the use of a software program to alter digital radiographs was investigated in this study, it shall be pointed out that this type of fraud is not attributed solely to digital radiographic systems, since each PC owner can modify and alter digitized images with free software programs that are available via Internet.

The possibility of hoax does exist in any profession, including dentistry. The most obvious rationale for fraudulent use of modified dental digital images may be both receiving authorization from dental insurance companies, and providing phony support for a particular medication, method, or approach. Whatever the rationale would be, it is unacceptable to tolerate unethical practice in any given profession. However, the precautions necessary to preclude this type of use of software programs shall be discussed and practiced, and the other parties object to fraudulent use of digital technology shall be warned, as well.

Recently, software producing companies have established measures to secure the original images by

adding embedded encryption, error correction-code memory, and digital watermarks.¹⁷ By using one of these modalities, authenticity of digital data may be provided easily, and fraudul use of digital images may be prevented eventually. Additionally, acceptance of only original radiographs during evaluation process of scientific manuscripts would be another way to preclude mishandling. Tsang et al.¹⁵ showed that after digitization of conventional radiographs and subsequent alteration of the images, the resultant images can be reverted and printed onto 35-m black-and-white photographic negative film. Then, printing the reversed images onto negative film strips provides images identical to those seen on the original radiographic film.¹⁵ However, this time-consuming, money and practice requiring process would be a less chosen method when compared to digital alteration and electronical transmission of radiographs.

As a conclusion, both the insurance companies and the editors of medical/dental journals should be informed and warned about the fraudulent use of software programs, and possible utilization of altered images. By application of the above-mentioned methods to secure the images, the possibility of this problem may be prevented, and originality of the images can be provided.

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Yazışma Adresi:

Doç. Dr. Pelin GÜRDAL

Ege Üniversitesi, Dişhekimliği Fakültesi
Oral Diagnoz ve Radyoloji Anabilim Dalı
35100 Bornova, İZMİR

Tel : (232) 3881081

Faks : (232) 3880325

E-posta : peleen_2000@yahoo.com