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Effect of digitization parameters on periapical radiographic image quality with regard to anatomic landmarks

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Resumo

O objetivo deste estudo foi avaliar a influência dos parâmetros de digitalização na qualidade da imagem radiográfica digital, com relação a reparos anatômicos. Para isso, imagens radiográficas foram digitalizadas por meio de um scanner (n = 160) com resoluções de 300, 600 e 2400 dpi. As imagens de 2400 dpi foram ainda diminuídas para 300 e 600 dpi antes do armazenamento. As digitalizações foram realizadas com e sem máscaras pretas utilizando-se escalas de cinza de 8-bit e 16-bit e salvas em formato TIFF. Para avaliar a influência dos parâmetros de digitalização na qualidade da imagem radiográfica digitalizada, quatro reparos anatômicos foram classificados por dois observadores (muito boa, boa, moderada, regular, pobre) em duas ocasiões diferentes. As concordâncias intra e inter-observadores foram avaliadas por meio do teste Kappa. Os resultados obtidos demonstraram que as concordâncias intra e inter-observadores variaram em função dos reparos anatômicos e da resolução utilizada. A junção cemento esmalte foi o reparo anatômico que apresentou a mais pobre concordância. A utilização da máscara preta favoreceu a qualidade da imagem digitalizada e seu uso é necessário para cobrir a radiografia durante o processo de digitalização. Portanto, a concordância variou de regular a moderada para a avaliação intra-observador e de regular a pobre para a concordância inter-observador.

Palavras-chave: Radiografia dentária; radiografia digital; processamento de imagem assistida por computador.

Abstract

The aim of this study was to evaluate the influence of digitization parameters on periapical radiographic image quality, with regard to anatomic landmarks. Digitized images (n = 160) were obtained using a flatbed scanner with resolutions of 300, 600 and 2400 dpi. The radiographs of 2400 dpi were decreased to 300 and 600 dpi before storage. Digitizations were performed with and without black masking using 8-bit and 16-bit grayscale and saved in TIFF format. Four anatomic landmarks were classified by two observers (very good, good, moderate, regular, poor), in two random sessions. Intraobserver and interobserver agreements were evaluated by Kappa statistics. Inter and intraobserver agreements ranged according to the anatomic landmarks and resolution used. The results obtained demonstrated that the cement enamel junction was the anatomic landmark that presented the poorest concordance. The use of black masking provided better results in the digitized image. The use of a mask to cover radiographs during digitization is necessary. Therefore, the concordance ranged from regular to moderate for the intraobserver evaluation and concordance ranged from regular to poor for interobserver evaluation.

Keywords: Radiography, dental; radiographic image enhancement; image processing, computer-assisted.

INTRODUCTION

The use of digital systems in dental clinic has increased significantly during recent years and is gradually replacing conventional radiography in that the dentist will store radiographic images of good quality and without damage. The cost to convert from conventional radiography to digital is high. It is anticipated that dentists will continue to convert to digital radiography slowly and that the cost of these devices will decline slowly[1].

One of the advantages of digital radiography, as compared with conventional radiography, is the possibility of adjusting an image's quality to improve it[2]. Although there have been rapid and recent developments in the use of dental digital imaging techniques[3,4], the digitization of the conventional radiography still is an alternative when considering the cost of adequate equipment. Currently, the digitization of periapical radiographs is also of importance in Brazil, since national law now requires dentists to store patients' data for 20 years. Whilst digital radiographic systems have been available in Dentistry since around 1980, lower costs have only now permitted more Brazilian dentists, especially radiologists, to acquire this technology. As such, the storage of periapical radiographs is still necessary.

Flatbed scanners are most often used to digitize conventional radiographs. Scanned images can be manipulated to aid diagnosis and scanning resolutions can be varied to alter the visibility of the details in the image. However, a major disadvantage of indirect digitization is the time involved, as conventional radiographs must be taken, developed, and scanned for viewing on a conventional computer monitor[5].

A study comparing diagnostic accuracy of D-speed and E-speed films in the detection of simulated periodontal bone lesions with an electronic direct digital image receptor showed no statistical difference[6]. However, it has been pointed out that the size and format of an image can affect the observer's performance[7] and the ability to detect some alterations in dentistry[6-8]. Therefore, the aim of this study was to evaluate the influence of digitization parameters on periapical radiographic image quality, with regard to anatomic landmarks.

MATERIAL AND METHODS

Ten conventional periapical radiographs were selected from the archive of the Dentomaxillofacial Radiology Section. This study was approved by the Ethics Committee (protocol nº 55/05). The digitization of the selected radiographs was performed with a flatbed scanner (Snapscan 1236s, Agfa-Gevaert N.V. – Woburn, MA, USA) at 300, 600 and 2400 dpi using 8-bit and 16-bit grayscale. The resolution of the digitized radiographs (2400 dpi) was then reduced to 300 and 600 dpi, before saving, in order to use less space on the hard disk. For digitization, the *Adobe Photoshop* 6.0 software (Adobe Systems Inc., San Jose, CA, USA) was used. Digitization was carried with and without black masking. Periapical radiographs were covered with a black mask with a clearance exactly matching the image size and shape to avoid scanning uncovered bright areas that would bias the acquisition and interpretation. The images were transferred to a desktop computer of 17-in. (AOC, Manaus, AM, Brazil), the screen resolution and the color display were set at 1024 × 768 pixels and 16-bit depth. In total, 160 digitized images were saved in uncompressed tagged-image file format (TIFF).

The digitized images were inserted into a black background file from Adobe with the same resolution as the digitized image, i.e., 300 or 600 dpi, in order not to show white edges. This software was also chosen to observe the following anatomic landmarks in the images: genial tubercules, lingual foramen, periodontal space, cement enamel junction (CEJ), which were each classified using a subjective 4-point scale of: 0 = image with bad quality for interpretation; 1 = image with regular quality for interpretation; 2 = image with good quality for interpretation and 3 = image with excellent quality for interpretation.

All digitized images were randomly coded. The images were shown to two blinded observers in two random sessions. The examiners received a short lecture with instructions about how to identify the anatomic landmarks. Adjustments of image contrast and brightness, along with magnification, were not permitted when analyzing the images[9,10]. No time limit was set for viewing the images, which was done in a darkened room at a viewing distance of 50 cm from the screen, the background of which was set at black. The evaluation session was performed twice with a 1 week-interval.

Intraobserver and interobserver agreements were evaluated by Kappa statistics (very good = 0.8-1.00, good = 0.6-0.79, moderate = 0.4-0.59, regular = 0.2-0.39, poor = 0.0-0.19).

RESULTS

Digitized 600 dpi resolution images presented the best intraobserver agreement, with the exception of 16-bit images that digitized with a mask, as shown in Table 1. Examiners analyzing the images indicated that the genial tubercule images were considered to be good when 600 dpi, 16-bit and no mask were used. According to Table 1, intraobserver agreement was similar for digitized images of 600 dpi and 2400-600 dpi at 8-bit and using a black mask. In general, the second examiner found good concordance when evaluating the radiographic image of the lingual foramen, considering all variables used to digitize the radiographs. Examiner two also found good agreement for the periodontal space for images digitized at 300 dpi at 8-bit with a black mask. Good intraobserver agreement was also found for images of 2400-300 dpi, although examiner 1 observed regular concordance for images at 16-bit without a mask. The examiners found good concordance for the cement enamel junction in images digitized with 2400-300 dpi at 16-bit with or without a black mask. This anatomic landmark presented the poorest concordance. Approximately half of the values presented for the CEJ presented observations of regular to poor. The best results were obtained using a mask, however, it was not possible to define the best resolution (dpi) for intrabserver agreement, since each anatomic landmark had a different performance according to each resolution.

Table 1. Intraobserver agreement for genial tubercules, lingual foramen, periodontal space and cement enamel junction, according to image resolution, bits and use of mask

Anatomic landmarks	Resolution (dpi)	Bits			
		8		16	
		WTM	WM	WTM	WM
Genial tubercules	300	0.21/0.31	0.49/0.55	0.29/0.33	0.44/0.52
	600	0.41/0.80	0.81/0.61	0.78/0.80	0.43/0.42
	2400-300	0.07/0.14	0.17/0.07	0.43/0.23	0.44/0.35
	2400-600	0.17/0.64	0.37/0.46	0/0.50	0.49/0.29
Lingual foramen	300	0.42/0.82	0.53/0.14	0.32/0.42	0.31/0.37
	600	0.11/0.58	0.60/0.64	0.15/0.52	0.12/0.82
	2400-300	0.17/0.09	0.47/0.60	0.31/0.42	0.80/0.23
	2400-600	0.80/0.67	0.66/0.63	0.14/0.63	0.39/0.62
Periodontal space	300	0.41/0.42	0.40/1.00	0.45/0.29	0.51/0.56
	600	0.48/0.80	0.28/0.78	0.84/0.60	0.25/0.67
	2400-300	0.69/0.53	0.52/0.78	0.23/0.83	0.52/0.60
	2400-600	0.39/0.67	0.67/0.60	0.24/0.40	0.33/0.60
Cement enamel junction	300	0.43/0.41	0.28/0.11	0.24/0.63	0.73/0.16
	600	0.32/0.58	0.65/0.18	0.20/0.20	0.33/0.25
	2400-300	0.38/0.44	0.39/0.12	0.62/0.62	0.60/0.62
	2400-600	0.09/0.67	0.31/0.78	0.68/0.40	0.51/0.05

*WTM = without mask; WM = with mask. [a]Kappa value was used to determine the intraobserver agreement (Examiner 1/Examiner 2).

As shown in Table 2, the best interobserver agreement for the radiographic image of the genial tubercules was observed for images digitized at 300 dpi with 16-bit and without a mask. When resolution was increased from 300 to 600 dpi, to 2400-300 dpi and finally to 2400-600 dpi, with a mask at 16-bit, images also presented high interobserver agreement for genial tubercules diagnosis. The interobserver agreement for diagnosis of the lingual foramen was considered poor to regular for the images without use of a mask at 8-bit and at 16-bit. Interobserver agreement increased when the periodontal space was identified in images digitized with a mask at 8-bit. The lowest values for interobserver agreement were found when analyzing the cement enamel junction image, with exception of the images of 2400-600 dpi, digitized without a mask.

DISCUSSION

The intraoral direct and indirect digital system has become increasingly used in the dental clinic. Digital radiography has many advantages, one being that the image is not static and can be manipulated for diagnosis purposes. Inter and intraobserver agreement was evaluated in this study using Kappa statistics. Tables presented herein demonstrate concordances ranging from regular to moderate for intraobserver evaluation and concordances ranging from regular to poor for interobserver evaluation. Some studies[5,11] focusing on the detection of caries have reported higher concordances than those of this study. We suggest that the classification of anatomic landmark images, based on their quality is more subjective than the detection of caries. Moreover, results may also be explained due to the examiners' difficulties in finding concordance for images of the cement enamel junction and lingual foramen. It should be pointed out that no post-processing was applied to the images in this study. Image processing (e.g. adjustment of contrast and/or brightness) could improve the quality of the displayed image[12] and could also improve interobserver concordance.

The choice of a resolution of 2400 dpi with reduction to 300 and to 600 dpi was made since these parameters were used when intra and extraoral radiographs were digitized for didactic purposes for presentation on Power Point software using a multimedia projector, in a classroom of approximately 80 seats; for this purpose images are magnified but do not lose quality. However, when using the CRT monitor, differences between the resolutions when analyzing different anatomic landmarks were not noted. In this study, the digitization of radiographs with a resolution of 2400 dpi and consequent reduction to 300 or 600 dpi for use on a multimedia projector also reduced the file size without loss of image quality, although higher resolution does not necessarily increase diagnostic accuracy[13].

Table 2. Interobserver agreement for genial tubercules, lingual foramen, periodontal space and cement enamel junction according to image resolution, bits and use of mask

Anatomic landmarks	Resolution (dpi)	Bits			
		8		16	
		WTM	WM	WTM	WM
Genial tubercules	300	0.20	0.44	0.70	0.29
	600	0.60	0.44	0.45	0.31
	2400-300	0.19	0.19	0.33	0.58
	2400-600	0.26	0.37	0.31	0.62
Lingual foramen	300	0.30	0.53	0.32	0.15
	600	0.19	0.20	0.21	0.54
	2400-300	0.03	0.34	0.45	0.03
	2400-600	0.08	0.49	0.40	0.29
Periodontal space	300	0.13	0.38	0.21	0
	600	0.48	0.28	0.64	0.39
	2400-300	0.69	0.28	0.38	0.50
	2400-600	0.84	0.67	0.33	0.33
Cement enamel junction	300	0.22	0.23	0.28	0.16
	600	0.48	0.29	0	0.31
	2400-300	0.29	0.29	0.64	0
	2400-600	0.66	0.47	0.67	0

*WTM = without mask; WM = with mask. [a]Kappa value was used to determine the interobserver agreement.

The best results for intraobserver evaluation were obtained using a black mask, in agreement with other studies that have used masking to digitize images[14,15]. However, it was not possible to define the best resolution (dpi) during intraobserver and interobserver evaluations, since each anatomic landmark presented a different performance, according to the chosen resolution. Considering the diversity of digitized image types, the interobserver evaluation did not allow the establishment of a parameter with regard to appropriate variables for digitizing radiographs. Thus, this study was unable to define the best parameter for digitizing periapical radiography, when the diagnostic task was to identify anatomic landmarks; although investigators[5,15,16] have suggested that resolutions of higher than 300 dpi did not contribute to the diagnostic task. According to the results of this study, the use of a black mask is necessary for digitizing radiographs. Furthermore, the image type had a significant effect on concordance for the identification of anatomic landmarks, as previously suggested by Janhom et al.[15] (2001) who stated that the depth of caries lesions affect their recognition.

CONCLUSION

Further studies are required to evaluate the effect of resolution on digitized images for the identification of anatomic landmarks, using fewer variables to provide positive results. The use of a black mask is necessary for digitizing radiographs. Such data could aid dentists when saving radiographic images, obtained previously, and/or during the introduction of the direct digital system in the clinic. In conclusion, concordance for the intraobserver evaluation ranged from regular to moderate and a concordance ranged from regular to poor for the interobserver evaluation.

REFERENCES

1. Christensen GJ. Why switch to digital radiography? J Am Dent Assoc. 2004; 135: 1437-9.
2. Dunn SM, Kantor ML. Digital radiology: facts and fictions. J Am Dent Assoc. 1993; 124: 38-47.
3. Sakurai T, Matsuki T, Nakamura K, Kashima I, Lee DL, Cheung LK, Jeromin LS. The development of a new direct digital extra-oral radiographic system prototype using a thin-film transistor panel. Dentomaxillofac Radiol. 1998; 27: 172-7.

4. Vandre RH, Pajak JC, Farman TT, Farman AG. Technical comparison of seven digital intra-oral dental X-ray sensors. Dentomaxillofac Radiol. 1997; 26: 282-3.
5. Kimmes NS, Saini TS, Carroll LR. Comparison of clinician agreement during visualization of conventional and digitized bitewing radiographs. Gen Dent. 2006; 54: 182-5.
6. Furkart AJ, Dove SB, McDavid WD, Nummikoski P, Matteson S. Direct Digital radiography for the detection of periodontal bone lesions. Oral Surg Oral Med Oral Pathol. 1992; 74: 652-60.
7. MØystad A, Savanaes DB, Larheim TA, Gröndahl H-G. Effect of image magnification of digitized bitewing radiographs on approximal caries detection: an in vitro study. Dentomaxillofac Radiol. 1995; 24: 255-9.
8. Dove SB, McDavid WD. A comparison of conventional intra-oral radiography and computer imaging techniques for the detection of proximal surface dental caries. Dentomaxillofac Radiol. 1992; 21: 127-34.
9. Grassl U, Schulze RKW. In vitro perception of low-contrast features in digital, film, and digitized dental radiographs: a receiver operating characteristic analysis. Oral Sur Oral Med Oral Pathol Oral Radiol Endod. 2007; 103: 694-701.
10. Peker I, Toraman AM, Usalan G, Altunkaynak B. The comparison of subjective image quality in conventional and digital panoramic radiography. Indian J Dent Res. 2009; 20: 21-5.
11. Abreu Júnior M, Tyndall DA, Platin E, Ludlow JB, Phillips C. Two- and tree-dimensional imaging modalities for the detection of caries. A comparison between film, digital radiography and tuned aperture computed tomography (TACT). Dentomaxillofac Radiol. 1999; 28: 152-7.
12. Berkhout WER, Verheij JGC, Syriopoulos K, Li G, Sanderink GCH, van der Stelt PF. Detection of proximal caries with high-resolution and standard resolution digital radiographic systems. Dentomaxillofac Radiol. 2007; 36: 204-10.
13. Fidler A, Likar B, Skaleric U. Lossy JPEG compression: easy to compress, hard to compare. Dentomaxillofac Radiol. 2006; 35: 67-73.
14. Attaelmanan A, Borg E, Gröndahl HG. Digitisation and display of intra-oral. Dentomaxillofac Radiol. 2000; 29: 97-102.
15. Janhom A, van Ginkel FC, van Amerongen JP, van der Stelt PF. Scanning resolution and the detection of approximal caries. Dentomaxillofac Radiol. 2001; 30: 166-71.
16. Radan E, Price C. Evaluation of digital and geometric unsharpness in dental radiographs using an endodontic file model. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002; 93: 208-14.

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