Effect of Image Compression on the Radiographic Diagnosis of External Root Resorptions.

Efeito Da Compressão Da Imagem No Diagnóstico Radiográfico De Reabsorções Radiculares Externas.

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RESUMO

Para avaliar o efeito da compressão JPEG sobre o desempenho no diagnóstico radiográfico de reabsorções radiculares externas, 33 incisivos centrais superiores foram montados em um simulador de tecidos e radiografados. Reabsorções radiculares externas de diferentes tamanhos foram simuladas seqüencialmente nas superfícies proximais de cada dente com brocas esféricas tamanho ¼, ½, 1, 2 e 3. Os dentes foram radiografados antes e após a confecção de cada cavidade. As imagens radiográficas foram digitalizadas, reproduzidas digitalmente e arquivadas no formato JPEG com níveis de compressão 12, 10, 8 e 6. As imagens foram apresentadas aleatoriamente a seis radiologistas que as classificaram quanto à presença de reabsorção de acordo com uma escala de 5 pontos. A compressão JPEG 10 reduziu o tamanho de arquivo em aproximadamente 60%, enquanto que esta redução para os níveis 8 e 6 foram 82% e 85%, respectivamente. A análise pela curva ROC não evidenciou diferenças significativas entre as imagens com diferentes níveis de compressão JPEG para nenhum dos tamanhos de reabsorção. A compressão JPEG nos níveis 12, 10, 8 e 6 resultou em imagens com o mesmo desempenho diagnóstico para reabsorções radiculares externas.

PALAVRAS-CHAVE:
Reabsorção radicular. Diagnóstico por imagem. Radiografia dentária digital

INTRODUCTION

External root resorption (ERR) is a pathological process that often results from dental trauma - reaching up to 50% of tooth avulsion cases (MAJORANA et al., 2003) - and is usually diagnosed by imaging methods, especially periapical radiographs (HINTZE et al., 1992).

Several digital image acquisition systems are currently available (WENZEL et al., 1996). Intraoral digital radiographs can be stored in full resolution, but the increasing demand for viable long-term archiving solutions and the rapid development of teleradiology makes the use of irreversible image compression inevitable (ERICKSON, 2002). Image data compression can reduce significantly the costs for image storage and transmission (SEERAM, 2006).

Medical radiology studies have investigated the impact of image compression on diagnostic accuracy (MacMAHON et al., 1991; ERICKSON et al., 1998). Several dental radiology researchers have also investigated this procedure, focusing on the effect of digital image compression on the diagnosis of caries (WENZEL et al., 1995; WENZEL et al., 1996; JANHOM et al., 1999; JANHOM; van der STELT; van GINKEL, 2000; PABLA et al., 2003), periapical lesions (KOENING et al., 2004), image quality (SIRAGUSA; MacDONNELL, 2002) or on the results of digital subtraction (MAHL et al., 2003; GEGLER; MAHL; FONTANELLA, 2006).

The Joint Photographic Experts Group (JPEG) compression format is a widely accepted standard and runs on multiple platforms. Each editing program has different interfaces for interaction with the operator, and, thus, uses a different compression scale (SIRAGUSA; MacDONNELL, 2002). The Photoshop software uses a compression scale of 0 to 12. The lossless JPEG algorithm preserves all information in each pixel of the original image with minimal reduction in file size, while lossy compression reduces file size but results in considerable loss of pixel information (JANHOM et al., 1999).

There is not a maximum compression ratio acceptable for all diagnostic tasks (ERICKSON, 2002). For this reason, new studies are required (FIDLER; LIKAR; SKALERIC, 2006). Therefore, the purpose of this study was to investigate the effect of image compression on the radiographic diagnosis of external root resorptions.

MATERIALS AND METHODS

Thirty-three upper central incisors were included in the study after visual and radiographic inspection to rule out resorptions. A simulator artifact was prepared by removing the anterior alveolar region of a maxilla from a dry skull and cutting out the buccal and palatal portions. These pieces were externally joined with a 2-cm-thick acrylic block to simulate soft tissues, and wax was interposed between them in the region where the teeth were to be placed.

Resorptions were randomly simulated on the proximal surfaces of each tooth, in the cervical, middle or apical thirds of the roots. Each tooth was removed from the simulator and drilled with # ¼, ½, 1, 2 and 3 round burs to simulate external resorptions of the root surface. The cavities were prepared by the penetration of all the cutting area of the bur into the root surface. Radiographs were taken between each drilling sequence.

A Spectro 70® (Dabi Atlante, Brazil) x-ray unit operating at 70 kV, 10 mA, at 0.7 s exposure time and 40-cm focus-film distance, was used to radiograph each tooth before and after the preparation of each cavity. Insight® (East-

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man Kodak Co, USA) films were used to acquire the images. The films were automatically processed (Dent-X 9000® - Dent-X, USA) in a 4.5-min cycle, with fresh processing solutions (X-Omat®, Kodak, Brazil).

The radiographs were digitized with an Epson Perfection 2450® scanner equipped with a transparency reader (Epson, USA) and an adapted black acrylic mask to standardize the scanning position and limit the incidence of light; brightness and contrast parameters were kept the same for all images. After capture, the Photoshop CS (Adobe, USA) software was used to digitally copy each radiographic image. Images were then saved in JPEG format at different compression levels - 12, 10, 8 and 6 -, in 8-bit format and 300 dpi, and stored in a disc.

A Microsoft PowerPoint® presentation on black background was prepared with the 792 resulting images organized in random order. Eighty of these images were digitally duplicated for the evaluation of reproducibility. Six trained radiologist, blinded to the source of image, individually evaluated the root surfaces of each tooth for presence or absence of external root resorptions and ranked them on a 5-point scale: 1 – definite absence of external resorption; 2 – probable absence of external resorption; 3 – unsure about presence or absence of external resorption; 4 – probable presence of external resorption; and 5 – definite presence of external resorption.

The intra-observer reproducibility was assessed using the Wilcoxon nonparametric test. The Kappa statistics was used to evaluate interobserver consistency for radiographic diagnosis. The agreement criteria was $K < 0.41$, poor; $K = 0.41–0.60$, moderate; $K = 0.61–0.80$, substantial; and $K = 0.81–1.0$, near perfect agreement.

Receiver operating characteristic (ROC) was employed to assess the performance of radiologists according to the different compression levels and resorption sizes. The areas under the curve (Az) represent the diagnostic accuracy of the image and were constructed using pooled data from the six observers.

RESULTS

Table 1 shows mean sizes of image files for each JPEG compression level. The JPEG 10 compression level reduced file size in over 60%, whereas reductions for levels 8 and 6 were 82% and 85%.

The Wilcoxon nonparametric test used to check the degree of intraobserver reproducibility in the repeated analysis of 10% of the cases (N=80) shows that there was no statistically significant difference between the scores in the first and the second evaluations for the same observer ($p > 0.5$).

The mean K values for each compression level were similar and ranged from substantial to near perfect agreement. The mean interobserver agreement ranged between 0.89 ± 0.063; 0.86 ± 0.096; 0.83 ± 0.092; 0.79 ± 0.087 for 12, 10, 8 and 6 compression levels, respectively.

Table 2 shows the values for area under the curve (Az), standard error (SE) and confidence interval (CI) for the evaluation of all images with and without resorptions (N=4752; 792 images and 6 observers). No statistically significant differences were found between the different JPEG compression levels.

***Figure 1** - Pooled ROC Curve for all images according to resorption size.*

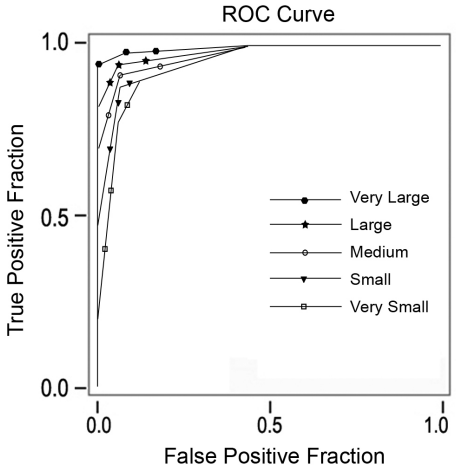

Figure 1 shows the pooled ROC Curves for the evaluation of images without resorption and with different resorption sizes: very small (# ¼ bur, N=66), small (# ½ bur, N=66), medium (# 1 bur, N=66), large (# 2 bur, N=66) and very large (# 3 bur, N=66). No significant statistic differences were found between the images at different JPEG compression levels for any of the resorption sizes.

***Table 1** - Mean sizes of image files for each JPEG compression level.*

JPEG level	Size (Kb)	Percentage of original	Approximate compression ratio*
JPEG 12	552.31	100	1:1
JPEG 10	217.06	39.30	1:2
JPEG 8	94.81	17.16	1:6
JPEG 6	82.05	14.86	1:7

** Compression ratio = original file size/file size after compression.*

***Table 2** - Results of pooled ROC analysis for all images in the sample according to JPEG compression level.*

JPEG level	Az	SE	CI	
12	0.977	0.003	0.971	0.983
10	0.976	0.007	0.962	0.990
8	0.974	0.012	0.950	0.998
6	0.966	0.018	0.930	1.000

Az: Area under the ROC curve
SE: Standard Error
CI: Confidence Interval

DISCUSSION

No studies about the impact of irreversible compression on the diagnosis of external root resorption were found in the literature. Different imaging methods, such as digital radiography and subtraction radiography (HEO et al., 2001), have been used to diagnose external root resorption, but success in accuracy has been partial.

In the present study we found no significant differences in the observers' performance in function of the cavity size, possibly due to the fact that all of them were made on proximal aspect of the roots.

It is much more difficult to detect the lesion when it is located on the buccal or palatal surface because the observer's ability is reduced when the resorption and the root canal, both radiolucent, overlap. The cavities on the proximal surfaces of the root are, in general, easier to detect (HEO et al., 2001).

Several studies (ANDREASEN et al., 1987; CHAPNIK, 1989; GOLBERG; DE SILVIO; DREYER, 1998) have demonstrated that small resorptive cavities are more difficult to diagnose than medium or large cavities, and that radiographs do not always detect small resorptions in the apical third of the root.

The JPEG 6 compression level (1:7) reduced file size in 85.14%. Results showed that image compression to this level does not significantly affect the detection of external root resorptions, regardless of the size of the cavities studied. We did not test the further compression rates because they result in a small relative reduction in file size.

These results of the present study are in agreement with other findings reported in the literature. Wenzel et al. (1995) have shown that images reduced to 8% of their original size do not affect the diagnosis of carious lesions. In a later study, Wenzel et al. (1996) found that the threshold for compression was about 1:20 for occlusal caries, and 1:12 for proximal lesions. Janhom et al. (1999) found that the 1:14 compression ratio can be used without affecting the diagnosis of caries when caries depth is considered, and that a 1:21.7 compression ratio resulted in greater observer error when the depth of lesion on enamel was evaluated.

The JPEG format is an irreversible compression algorithm, which means that the image resulting from decompression may not be identical to the original image (WENZEL et al., 1996). However, there is previous evidence that low and moderate compression ratios do not impact detectability of chemically-induced periapical bone lesions (KOENING et al., 2004). In spite of a slightly smaller number of correct identifications in more compressed images, compression at rates up to and including 1:7 did not affect the performance of radiographic diagnosis of simulated external root resorptions.

The results of this in vitro study cannot be directly transposed to in vivo situations, but are very important in the establishment of solid bases for further studies, particularly in developing countries, where the costs for computer storage are yet expensive.

CONCLUSION

No decrease in diagnostic accuracy for simulated external root resorptions was observed with low and moderate compression of digitized radiographs.

ABSTRACT

To investigate the effect of JPEG image compression on the diagnostic accuracy of external root resorptions, 33 central upper incisors were mounted in a maxilla simulator artifact and radiographed. Sequential external root resorptions of different sizes were simulated on the proximal surfaces of each tooth with ¼, ½, 1, 2 and 3 round burs. The teeth were radiographed before and after each cavity was drilled. Each radiographic image was digitized, digitally copied and stored as JPEG image files at 12, 10, 8 and 6 compression levels. The images were randomly presented to six radiologists that ranked resorptions on a 5-point confidence scale. The JPEG 10 compression level reduced file size in about 60%, whereas reductions for levels 8 and 6 were 82% and 85%. Receiver operating characteristic analysis did not reveal any statistically significant difference between the images at different JPEG compression levels for any of the resorption sizes. The JPEG 12, 10, 8 and 6 compression levels resulted in images with the same diagnostic performance for simulated external root resorptions.

KEYWORDS

Root resorption; Diagnostic imaging; Dental digital radiography

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