

EFFICACY OF CONVENTIONAL AND DIGITAL RADIOGRAPHIC IMAGING METHODS FOR DIAGNOSIS OF SIMULATED EXTERNAL ROOT RESORPTION

EFICÁCIA DOS MÉTODOS RADIOGRÁFICOS CONVENCIONAL E DIGITAL NO DIAGNÓSTICO DE REABSORÇÕES RADICULARES SIMULADAS

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ABSTRACT

This in vitro study evaluated and compared the efficacy of conventional (Kodak F-speed (Insight), Kodak) and a digital (DRS Gnatus System, Gnatus) radiographic imaging for diagnosis of simulated external root resorption cavities. Human mandibles containing teeth were covered with bovine muscle slices in order to simulate the soft tissues. Nine teeth out of each group of teeth were investigated. Initially, three periapical radiographs of each tooth were taken using a tube shift technique with mesial and distal angulations in both methods. All teeth were subsequently extracted and had 0.7 and 1.0-mm deep cavities prepared on their buccal, mesial and distal surfaces at the cervical, middle and apical thirds. Steel cylinder burs (DORMER® - HSS) with 0.7 and 1.0-mm diameter were used. Each tooth was replaced on its socket and new radiographs were taken. Three examiners, an endodontist (1), a radiologist (2) and a general dentist (3), evaluated the images. Results were compared by z-test and showed a higher number of cavities detected by the digital method compared to the conventional, regardless of the deepness of the cavity. In decreasing order, examiners 2, 3 and 1 exhibited different potentials of detection of cavities with the conventional method. Examiners 1 and 3 exhibited superior potential than examiner 2 for detection of cavities of different sizes with the digital method.

UNITERMS: External root resorption; Direct digital radiography; Dental radiography.

RESUMO

O presente estudo visou avaliar e comparar, *in vitro*, a eficácia dos métodos radiográficos convencional (filmes de grupos de sensibilidade E/F Kodak *Insight*) e digital (Sistema Gnatus DRS), no diagnóstico de cavidades simulando reabsorções radiculares externas, em dentes contidos em mandíbulas humanas secas com músculo bovino simulando o tecido mole. As variáveis consideradas foram: tamanhos das cavidades e examinadores envolvidos. Foram utilizadas nove unidades de cada grupo dentário, incisivos (central e lateral), caninos, pré-molares e molares, sem lesões periapicais, as quais foram radiografadas inicialmente, em três tomadas radiográficas periapicais (orto, mesio e distorradial) pelos métodos radiográficos convencional e digital. Extraíram-se os dentes com o auxílio de fórceps e as cavidades de reabsorção foram confeccionadas com brocas cilíndricas DORMER® - HSS - Aço rápido, de 0,7 e 1,0 mm de diâmetro, nas profundidades 0,7 e 1,0 mm, para simular cavidades pequenas e médias, respectivamente, distribuídas nos terços radiculares cervical, médio e apical e nas faces vestibular, mesial e distal. Após a realização das cavidades os dentes eram reposicionados nos alvéolos e então, radiografados novamente pelos métodos convencional e digital, sendo esses passos comuns a ambos os diâmetros e profundidades das cavidades. As radiografias convencionais e digitais foram avaliadas por três cirurgiões-dentistas, sendo um radiologista, um endodontista e um clínico geral. Os resultados da investigação mostraram que, pelo método radiográfico digital o número de cavidades observadas foi maior do que pelo convencional, tanto para as cavidades pequenas ($p < 0,05$), quanto para as médias ($p < 0,05$).

UNITERMOS: Reabsorção radicular externa; Radiografia digital direta; Radiografia dentária.

INTRODUCTION

Root resorption is a clinical condition associated to a physiological or pathological process resulting in the loss of mineralized tissues such as dentin, cementum and alveolar bone¹⁴.

The mineralized tissues located at the inner surfaces of the root canal are protected by the pre-dentin and the odontoblast layer, while the tissues at the outer surfaces are protected by the pre-cementum, cementoblasts and periodontal ligament. Such barriers avoid resorption of these tissues in normal conditions. However, the mineralization of some of these structures, as well as the dislodgment and/or damage of the pre-cementum, can induce resorption of the denuded tissues by allowing their colonization by multinuclear cells^{14,15}.

Root resorption is an asymptomatic clinical condition, detected in radiographic examinations targeted to other clinical situations, being the most important diagnostic tool for that condition. Additionally, the chances to treat and maintain the affected tooth become minimal when occasional diagnoses occur late. Thereby, radiographic exams are of great value to detect the process in early stages and enhance the treatment and prognosis.

The resorption cavity is the main target focused in the radiographic examination of root resorption. However, several authors have shown differences between the radiographic aspect and histological condition of the affected areas of the tooth^{1,12,14,17}. Moreover, the cavity must have certain dimensions in order to be radiographically detected²³. Besides these concerns, the superimposition of mineralized structures over the pathological processes and the inherent difficulties of the technique make detection of initial lesions difficult.

The importance of the early diagnosis of dental root resorption and the use of dental digital radiographic imaging on this process becomes a worthy issue to be evaluated. Thus, this study compared the efficacy of conventional and digital radiographic imaging methods in the diagnosis of external dental root resorption as a function of cavity size and examiner.

MATERIALS AND METHODS

Six dry human mandibles containing teeth were obtained from the collection of the Pontifical Catholic University of Parana (Curitiba campus, Brazil). After radiographic examination, an overall of nine teeth of each dental group (I, C, PM and M, total of 36) without signs of apical pathology were selected for this study.

Initially, three periapical radiographs of each tooth were taken in orthoradial, mesial and distal angulations using the proposed methods. Exposure times were 0.12 and 0.10 seconds for conventional and digital radiographic methods, respectively. The gingiva (buccal and lingual) and the cheek were simulated with bovine muscle slices measuring 1.5mm and 10mm in thickness, respectively.

Conventional radiographs were taken with an X-Ray machine (Gnatus IntraOs 70, Gnatus, Ribeirao Preto, Brazil) at 6mA, focal spot of 0.8mm and 70kVp. A device with two plastic plates oriented at a 90-degree angle assisted in the correct position of the radiographic films parallel and next to the target. The focal spot-to-film distance was 30cm. Exposures at mesial and distal angulations were obtained by moving the cylinder in 15 degrees. The radiographic films used were Kodak *Insight*[®] (Eastman Kodak Co, Rochester, NY, USA), E/F speed. The films were processed in Kodak GBX[®] solutions (Kodak Brasileira Com. Ind. LTDA., Sao Jose dos Campos, Brazil) using the time-temperature method in dark room under safety light.

Digital radiographs were taken using a digital radiography system (Digital Gnatus DRS, manufactured by Gnatus LTDA, Ribeirao Preto, Brazil, and Cygnus Technologies LLC, Arizona, USA) with a charge-couple device (CCD) detector size 1 with 312,000 pixels, 10 to 12 lines of resolution, spots of 44-micron and a detector's active area of 604mm². The system was handled according to the manufacturer's instructions.

After achievement of the initial radiographs, all teeth were extracted and had cavities of 0.7mm in depth and 0.7mm in diameter prepared on the buccal, mesial and distal surfaces at the cervical, middle and apical thirds. Cavities at the distal surface of the mesial root and mesial surface of the distal root of the molars were not drilled due to the difficult access. All cavities were drilled with steel cylinder burs (DORMER[®] – HSS) with 0.7-mm diameter attached to a drilling machine (INTOS[®], Zebrók, FNGJ32, Republic Czech, 220 V, 160Hz, 6.5kVa and 2000rpm) containing a digital numerical reader (Heidenhain, Germany, 0.0001mm resolution). The coordinates X (longitudinal) and Y (transversal) recorded the location of each cavity, while the coordinate Z recorded their depth. All teeth were fixed with pressure pliers (Gedore Vanadium[®], N137-10) attached to the grip of the drilling machine. After drilling the cavities, the teeth were remounted on their sockets and conventional and digital radiographs were retaken.

In the sequence, all teeth were again detached from their alveolus and the cavities were enlarged to 1.0mm in depth and 1.0mm in diameter using steel cylinder burs with 1.0-mm diameter and the same method described to prepare the 0.7-mm depth cavities. The teeth were then remounted on their sockets and conventional and digital radiographs were retaken for the third time.

A total of 27 images of small cavities (0.7mm in depth x 0.7mm in diameter) and 27 images of medium cavities (1.0mm in depth x 1.0mm in diameter) were taken for the incisors, canines and premolars. A total of 54 images, 27 for each root (mesial and distal), were obtained for the molars. The entire number of observations was 810, with 270 for each examiner (135 for small cavities and 135 for medium cavities).

Three dental professionals, namely a radiologist, an endodontist and a general dentist, were oriented and evaluated the digital and conventional radiographs without comparing them. Except for magnification at 36%, further manipulation of the digital images was not allowed.

Radiographs of the teeth without cavities, with small cavities and with medium cavities were evaluated separately in this order at intervals of one week. Digital and conventional radiographs were also evaluated at intervals of one week. Thereby, the total time analysis comprised 12 weeks.

The radiographic films were analyzed over a view box with diffuse light and under 4x magnification. A dark card mask delimited the area to be examined. Digital images were examined in a 14-inch (13.3-inch viewable size) SVGA monitor (Samsung, SyncMaster 450b) with a resolution of 800 x 600 dpi at a frequency of 85Hz.

The presence or absence of cavities detected by the examiners was compared by z-test as a function of the cavity's size, radiographic imaging method and examiner.

RESULTS

The number of cavities detected by the digital radiographic method (653) was statistically higher ($p < 0.05$) than that detected by the conventional radiographic method (542).

Table 1 shows the total number of small and medium cavities detected by the two radiographic methods. The results show that, regardless of the size of the cavity, the digital method revealed a statistically higher number of cavities ($p < 0.05$). Additionally, the number of medium cavities was statistically superior to that of small cavities ($p < 0.05$).

Table 2 shows the number of cavities individually detected by each examiner with the radiographic methods evaluated. The results showed that the endodontist ($p < 0.05$)

and the general dentist ($p < 0.05$) observed a statistically higher number of cavities with the digital method compared to the conventional. The radiologist observed the same number ($p > 0.05$) of cavities with both methods. Results also detected a statistically significant difference in the number of cavities observed by the radiologist ($p < 0.05$) compared to the endodontist and general dentist for the conventional method.

Table 3 shows that the number of small cavities observed by the radiologist was statistically higher for the conventional radiographic method ($p < 0.05$), while no differences were detected for medium cavities with both methods ($p > 0.05$). The number of small and medium cavities observed by the endodontist and the general dentist, separately, was statistically higher ($P < 0.05$) with the digital radiographic method.

DISCUSSION

This study compared the efficacy of conventional and digital radiographic imaging methods in diagnosing simulated root resorption cavities. The results revealed a higher number of cavities detected by the digital radiographic method compared to the conventional method. Among the 810 observations (270 for each examiner, 135 for small cavities and 135 for medium cavities) simulating root resorption, the conventional method detected 542 (66%) cavities, while the digital method detected 653 (86%).

As regards the size, the medium cavities allowed a higher percentage of detection for both dental radiographic imaging

TABLE 1- Total number of small and medium cavities detected by the imaging methods

Cavities	Conventional	P1	Digital	P2	p value
Small	235	0.57	291	0.70	0.0000
Medium	307	0.74	362	0.88	0.0000
p value	0.0000		0.0000		

P1 and P2= proportion of favorable cases; n=405

TABLE 2- Number of cavities detected by the examiners with the radiographic methods

Radiographic method	Conventional	P1	Digital	P2	p value
Radiologist	221	0.82	207	0.77	0.1507
Endodontist	154	0.57	221	0.82	0.0000
General dentist	167	0.62	225	0.83	0.0000
p value P(1,2)	0.0000		0.1507		
p value P(1,3)	0.0000		0.0819		
p value P(2,3)	0.2372		0.7589		

P1, P2 and P3 = proportion of favorable cases; n=270

methods. This finding was expected due to the larger amount of dentinal tissue removed, thus showing larger radiolucent areas. This finding is in accordance with those of Andreasen, et al.¹, Chapnick⁷ and Goldberg, et al.¹⁰ for the conventional radiographic method, and with those of Levander, et al.¹³, Borg, et al.² and Clasen⁸, who compared conventional and digital radiographic imaging methods. The digital method has detected a higher number of small (70%) and medium (88%) cavities than the conventional method (57% and 74% respectively). An explanation for such finding might be the magnification of the digital images up to 36%, compared to the 4x magnification employed with the conventional radiographic film.

Modification of the horizontal angle increased the chances to detect the cavities when they had not been observed in the orthoradial image. In some cases, the cavities were visualized on the images achieved at mesial and/or distal angulation. This finding is in agreement with those of Brynolf^{3,4,5,6}, Andreasen, et al.¹, Goldberg, et al.¹⁰ and Westphalen¹⁶.

The digital radiographic images were analyzed without previous manipulation, except for magnification of up to 36% to simulate the clinical conditions of a dentist on an ordinary daily dental practice. The use of additional image manipulation would be one more variable to be considered and could also interfere with the results of the study by distorting the standardization of the method.

The results of this study are similar to those reported by Clasen⁸. However, the latter investigated simulated cavities of 0.5, 0.8 and 1mm of diameter in maxillary incisors and made use of tools offered by the software. The author also pointed the possibility to magnify digital images in comparison to the limited options of the view box and lens for the conventional radiographic methods.

Borg, et al.² compared the efficacy of one conventional and two digital radiographic methods to detect root defects with 1.2-mm diameter and 0.6 to 0.9mm in depth in mandibular teeth fixed on dry human mandibles. The radiographs were taken in orthoradial direction and the examiners were allowed to alter the brightness and contrast of the digital images. The results revealed no statistically significant differences between the methods.

In a similar study, Levander, et al.¹³ examined

conventional and digital radiographs of simulated cavities of 0.6, 1.2 and 1.8-mm diameter and 0.3, 0.6 and 0.9mm in depth in mandibular premolars. Even though the radiographic positions were orthogonal and eccentric for both imaging methods, the results were similar to those of Borg, et al.².

CONCLUSIONS

Within the limitations and results of this study, it can be concluded that:

- The examiners, on the following decreasing order, exhibited different potentials to detect cavities of different sizes with the conventional method: radiologist, general dentist and endodontist;
- The endodontist and the general dentist exhibited superior potential than the radiologist to detect cavities of different sizes with the digital method;
- The radiologist detected more cavities with the conventional method than with the digital, in comparison to the endodontist and general dentist;
- The general dentist exhibited the highest potential to detect small cavities with the digital method, followed by the endodontist and the radiologist; for medium cavities, the radiologist exhibited the highest potential followed by the general dentist and endodontist.
- Regardless the size of the cavities, the digital radiographic imaging method detected a higher number of cavities compared to the conventional method.

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TABLE 3- Number of small and medium cavities detected by the examiners with the radiographic methods

Examiner	Cavity	Conventional	P1	Digital	P2	p value
Radiologist	Small	100	0.74	82	0.61	0.0234
	Medium	121	0.90	125	0.93	0.3776
Endodontist	Small	64	0.47	104	0.77	0.0000
	Medium	90	0.67	117	0.87	0.0001
General dentist	Small	71	0.53	105	0.78	0.0000
	Medium	96	0.71	120	0.89	0.0003

P1 and P2 = proportion of favorable cases; n=270

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