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Accuracy of digital Radiography in the detection of Root Fractures in Multirooted Teeth

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Abstract— *This study aimed to evaluate the contribution of filters of CliniView™ software on detection of vertical root fractures of multirooted teeth with intracanal metal retainers on periapical digital radiographs. For this, 22 human teeth were randomly divided into fractured group and control group, each one containing 11 teeth. The teeth were endodontically treated and after desobturation of ⅔ from the root, intracanal metallic posts were installed. The fractures were made only in the fractured group, and all teeth were x-rayed using an Express™ intraoral digital system and the images optimized in Cliniview™ software. The analysis of radiographs was made for 2 specialists with, at least, five years of experience in the area. The original images were evaluated, with application of filters Sharpen 1, grayscale inversion, emboss, vertical and vertical + horizontal, separately. After analysis, the accuracy, sensitivity, specificity, positive and negative predictive value of original periapical radiography were calculated and with the use of filters, for each evaluator. The filter "sharpen 1" had the highest accuracy (0.652) and sensibility (0,543). On the other, the filter "grayscale inversion" had the highest specificity (0.955). The interobserver kappa index was 0,351, considering p<0,001 and interobserver kappa 0,333 and 0,512 for the evaluators 1 and 2 respectively. It is concluded that the contribution of the filters is professional-dependent and, in this study, the filter "sharpen 1" contributed to all of images evaluated, differently from the filter "grayscale inversion", that disturbed the radiographic diagnosis of root fracture in multirooted teeth.*

Keywords— ***dental radiography, fractures of teeth, digital radiography.***

I. INTRODUCTION

The vertical root fractures (VRF) are characterized by a line oflongitudinal fracture, that can propagate from the cervical part to the apex and is limited to the root of the tooth and may extend from the pulp to the periodontium[1].

The etiology of VRFs is multifactorial, and may be caused by physical and occlusal trauma, pathological resorption, repetitive parafunctional habits, instrumentation technique, susceptible dental anatomy, as well as iatrogenic complications during and after endodontic treatment, which involves instrumentation of the canal, excessive force during the condensation of the obturator material and placement of intracanal metal retainers[2,3,4.5].

The signs and symptoms of VRFs are diverse and may vary according to the dental group, position of the fracture, time after the fracture, periodontal condition and bone architecture of the area adjacent to the fracture[6]. Clinically, pain, edema, dental mobility, periodontal pocket, fistula, abscess or sensitivity to palpation and percussion can be observed[7]. In several cases, teeth with VRF have a long history of discomfort and/or pain ranging from mild to moderate, being rarely severe[6,8].

In this way, most of diagnosis can only be reached after a combination of clinical signs and radiographic findings. However, the signs and symptoms of VRFs can be confused with those present in periodontal disease, failures in endodontic treatment or with the presence of accessory canals. Due to the non-specificity of their clinical signs and radiographic findings, their diagnosis becomes a difficult task[9].

Periapical radiographs have been used to assist in diagnosis of VRFs due to their common presence in practical routine, as well as low cost and low radiation

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dose. However, these two-dimensional images are intrinsically affected by overlapping structures, making diagnosis difficult[9,10,11].

Taking this into consideration and with the advent of the digital system, the possibility of image enhancement through computational resources in two-dimensional images examination arose. Some studies bring alternatives to increase the accuracy of the VRFs diagnosis, such as the use of filters in digital periapical radiographs on single-rooted teeth[12,13,14,15].

An alternative to the diagnosis of VRF would be Cone-Beam Computed Tomography (CBCT) for the possibility of examine the image in three dimensions, as well as the observation in several planes: axial, sagittal, and coronal, without overlapping structures[16,17]. However, the presence of intracanal metallic retainers are limiting factors for diagnosis when producing artifacts in the CBCT image, as well as the high radiation doses of this exam and its high cost compared to the radiography[18,19].

Thus, the present study aimed to evaluate the contribution of "*sharpen* 1", "grayscale inversion", "*emboss"*, "vertical" and "vertical + horizontal" filters of the CliniView™ *software* in the detection of vertical root fractures of multirooted teeth in periapical digital radiographs.

II. MATERIAL AND METHODS

2.1 Sample selection and tooth storage

This project was approved by the local Review Board under number 447.315, in 2013. For its accomplishment, 22 multirooted teeth were selected (11 for the fractured group and 11 for the control group), extracted from patients of the School of Dentistry of the Federal University of Goiás.

2.2 Endodontic treatment and metal retainer placement

The crowns of the teeth were sectioned at the cement-enamel junction with a diamond disc. Then, the canal was explored until the apical foramen with file to verify the total clearance of the conduit and foraminal opening. The root canals were instrumented by the hybrid technique. The cervical and middle thirds were prepared with G*ates-Glidden*drill, followed by *Pro Taper*® rotatories (Dentsplay Maillefer, Tulsa, UK). The root canal obturation was obtained by the active lateral condensation technique and the main cone was chosen according to the diameter of the apical third enlargement.

The resin cement RelyX U200 (3M ESPE, Sumaré, SP, Brazil) was used for the cementation of cast metal posts, according to the manufacturer's orientation. The metal post was placed in position with digital pressure and the excess cement removed with an explorer, after previous light curing.

2.3 Confection of vertical root fractures

The fractures were only accomplished on the fractured group with aid of a hammer, in accordance with the protocol proposed by Abdinian, Razavian and Jenabi (2016)[20].

2.4 Radiographic Examinations

A dissected human mandible of the Department of Radiology of the School of Dentistry of Federal University of Goiás, with the alveolar processes present, was used as a phantom (Img. 1). In order to simulate the attenuation of the X-ray beam by soft tissue, wax was placed in the mandible in the vestibular aspect. The digital periapical radiograph was taken.For this purpose a phosphor plate number 2 was used and the Focus periapical radiography equipment (Kavo, Brazil), with focal tube of 0,8 mm X 0,8 mm, by the parallelism technique, using orthocentric incidence.

Fig. 1: Tooth in the alveolus of the mandible for radiographic image acquisition.

The original images were saved to be adjusted in *CliniView™ software.* The optimized images had activated the tool "calculate brightness according to the contrast". This tool had the function of adjusting the brightness value according to the contrast acquired by the image. Afterwards, five possibilities of adjustments to improve the image quality were made for comparison: application of *sharpen* 1, grayscale inversion, *emboss*, vertical and vertical plus horizontal filters (Img. 2). The images were saved and identified by letters: protocol A (*sharpen* 1), B (grayscale inversion), C (*emboss*), D (vertical), E (vertical + horizontal) and F (original).

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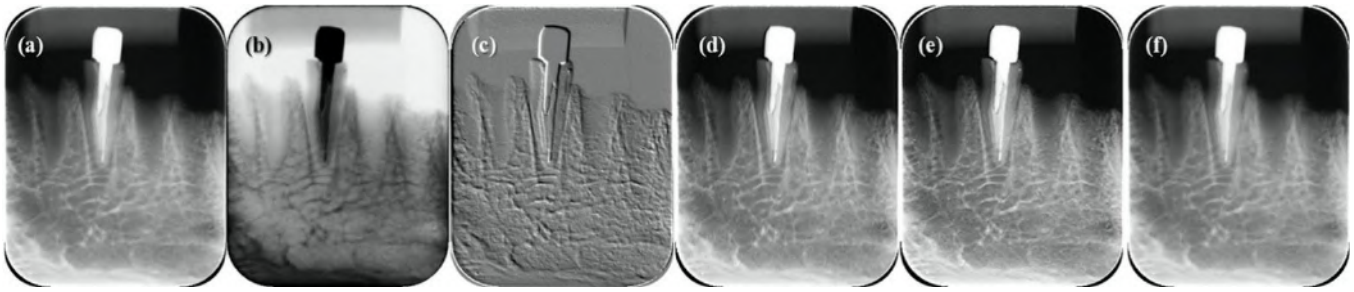

Fig.2: (a)sharpen 1, (b) grayscale inversion, (c) emboss, (d) vertical and (e) vertical + horizontal filters.

Table 1: Inter and intraobserver kappa value

	Evaluator 1	**Evaluator 2**
Evaluator 1	0,333	0,351
Evaluator 2	-	0,512

Table 2: Accuracy, specificity, sensitivity, PPV and NPV

Image	Accuracy	Specificity	Sensitivity	PPV	NPV
Original	0.490	0,818	0,408	0,702	0,579
Sharpen 1	0.652	0,769	0,543	0,685	0,641
Grayscale inversion	0.248	0,955	0,180	0,875	0,547
Emboss	0.545	0,906	0,453	0,889	0,635
Vertical	0.643	0,861	0,544	0,794	0,657
Vertical + Horizontal	0,588	0,767	0,499	0,690	0,607

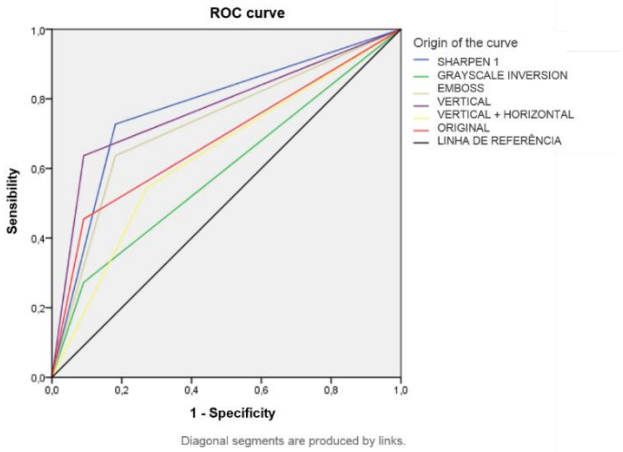

Fig. 3: ROC curve for evaluator 1

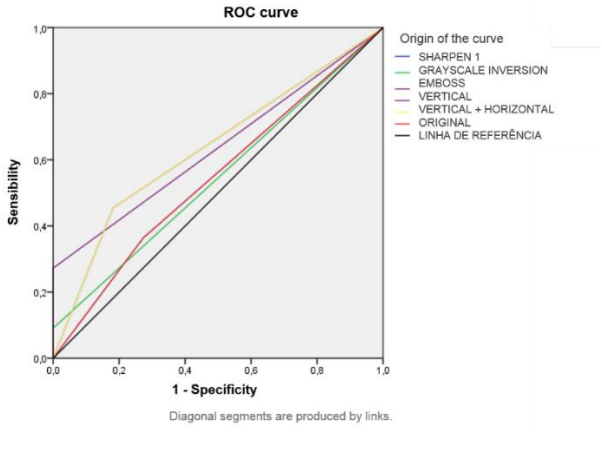

Fig. 4: ROC curve for evaluator 2

III. DISCUSSION

The purpose of this study was to evaluate whether digital improvement filters influence the diagnosis of VRFs in multirooted teeth. Our results showed that the filters had higher accuracy values than the original image, except the "grayscale inversion". The filter that presented

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the highest value for sensitivity was the "vertical" and the filter that presented the highest value for specificity was the "grayscale inversion".

The highest value of accuracy was observed on the images that were applied to the "*sharpen* 1" filter. This result is similar to that of Nascimento et al. (2015), who despite using a direct digital radiography system (*Digora™ Optime*), and single-rooted teeth, found that the "*sharpen* 1" filter assists in the radiographic diagnosis of vertical fractures.

Regarding sensitivity, that is, the ability of the examination to detect the fracture when the tooth is actually fractured, this work showed that the "vertical" filter had the highest values. Differently from the work of Tofangchiha et al. (2012), who showed in his study, with single-rooted teeth and coupled loading device, that the original image obtained higher sensitivity when compared to filters. The "vertical" filter uses algorithms that aim to highlight the vertical lines of the radiographs and probably, therefore, the fracture lines were more easily detected by evaluators of this study.

Queiroz et al. (2016), when using images with "*emboss*" filter, with the DBSWIN™ *software* on single-root teeth and photostimulated phosphorus plates, concluded that due its acceptable diagnostic accuracy, it is an imaging modality that should be used for the diagnosis of VRFs. In the present work, the "*emboss*" filter also presented a high value of specificity (0,906), that is, approximately 91% of the cases without fractures were correctly diagnosed.

No studies evaluating the VRF and the "vertical + horizontal" filter were found in the literature. This tool aims to highlight the vertical and horizontal lines and, in this way, it was believed that the visualization of the vertical and transversal fracture lines was facilitated. The accuracy value for this filter, in this study, was higher than the original radiography, however, this difference was not significant.

The low value of interobserver kappa in this study reflects the difficulty in diagnosing VRF in periapical radiographs, and is in accordance with other studies that reported low levels of interobserver agreement[14,21]. The improvement of digital systems tools and effectiveness depends on the experience of the observer, which may contribute to such values[13].

This study compared the use of original images and with the application of *software* filters *Cliniview™* in the detection of VRFs in multirooted teeth through two observers. In the literature researched, no studies were found comparing the diagnostic accuracy of digital enhancement filters in the diagnosis of VRFs in multirooted teeth.

The limitations of the present study are inherent to an *ex vivo* in which the actual clinical cannot be completely simulated[22].

The values obtained with the filters were higher than the original, except the "grayscale inversion" and there was still a relevant variation among the evaluators, but more studies are needed, in multirooted teeth in order to compare the efficacy of image enhancement tools.

IV. CONCLUSION

It is concluded that the contribution of the filters is professional-dependent and that, in this work, the "*sharpen* 1" filter contributed to all images evaluated, differently from the "grayscale inversion" filter, which impaired the radiographic diagnosis of root fractures in multirooted teeth.

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