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A comparative study of the conventional and digital intraoral radiography methods for root canal length measurement

Comparação entre Radiografia intraoral convencional e digital para medição de comprimento do canal radicular : estudo in vitro

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ABSTRACT

Objective: Measurement of root canal length is one of the most important stages of endodentic treatment, and any error at this stage can lead to the failure. This study aimed to compare conventional and digital intraoral radiography in measurement of root canal length. **Material and Methods:** In this study, 35 single-canal maxillary teeth were collected. Access cavities were prepared. An endodontic number 10#K- file was introduced into the canal, until the tip was visible at the apical foramen and the actual canal length (gold standard) was determined. After acquisition conventional radiographs using E-Ektaspeed and F-Insight film (Eastman-Kodak Co. Rochester, NY, USA) and digital radiographs using Photostimulable Phosphor Plates(PSP) (Soredex, Helsinki, Finland) and Charge Coupled Devices (CCD)(RVG, Trophy,NY,USA). they were examined separately with a two-week interval by two oral and maxillofacial radiologists. The data were analyzed with ANOVA and Tukey's tests using SPSS-19 software (SPSS Inc., Chicago, IL, USA). **Result:** No statistically significant difference was observed between different radiographies, and different observers ($P > 0.05$). Nevertheless, in comparison with the gold standard, in all cases, the F-speed conventional radiography and the digital CCD radiography showed the highest and the lowest accuracy, respectively. Also, the PSP and the E-speed conventional radiography were in the second and third order of accuracy, respectively. **Conclusion:** The use of digital radiography does not improve the accuracy of the root canal length measurement,but the digital technique has advantages,such as the reduced patient exposure, eliminating the time consuming processing stages, and producing fast images.

KEYWORDS

Conventional radiography; Digital radiography; Root canal, radiography; Root canal length

RESUMO

Objetivo: A medição do comprimento do canal radicular é uma das etapas mais importantes de tratamento endodôntico, e qualquer erro nesta fase pode levar ao fracasso. Este estudo teve como objetivo comparar a radiografia intra-oral convencional e digital na medida do comprimento do canal radicular. **Material e Métodos:** Neste estudo, 35 dentes superiores com canal único foram coletados. Cavidades de acesso foram preparadas. Uma lima endodôntica tipo K, número 10 foi introduzida no canal, até que a ponta era visível no forame apical e o comprimento do canal real (padrão ouro) foi determinada. Após a aquisição de radiografias convencionais, utilizando os filmes E-Ektaspeed e F- Insight (Eastman Kodak Co., Rochester, NY, EUA) e radiografias digitais utilizando placas foto estimuláveis de fósforo (PSP) (Soredex, Helsinki, Finlândia) e dispositivos de acoplamento (CCD) (RVG, Troféu, NY, EUA), as mesmas foram examinadas separadamente com um intervalo de duas semanas, por dois radiologistas oral maxilofaciais. Os dados foram analisados pelos Testes de ANOVA e Tukey utilizando o software SPSS-19 (SPSS Inc., Chicago, IL, EUA). **Resultados:** Não houve diferença estatisticamente significativa entre as diferentes radiografias, e observadores diferentes ($P > 0,05$). No entanto, em comparação com o padrão-ouro, em todos os casos, a radiografia convencional e a radiografia digital CCD apresentaram o maior e a menor precisão, respectivamente. Além disso, a PSP e a radiografia convencional estavam na segunda e terceira ordem de precisão, respectivamente. **Conclusão:** O uso da radiografia digital não melhora a precisão da medição do comprimento de canal, mas a técnica digital tem vantagens, tais como a exposição do paciente reduzida, eliminando o demorado estágio de processamento, produzindo assim, imagens mais rápidas.

PALAVRAS-CHAVE

Radiografia dentária; Radiografia dentária digital, Cavidade pulpar, radiografia; Comprimento do canal radicular.

INTRODUCTION

Success in endodontic treatment relates in part to the length of the final filling of the root canal. After achieving a convenient access and finding the root canal orifice, an appropriate and reliable measurement of the root canal length must be made; this is of great importance because measurement of the root canal length is the basis for the preparation and the determinant of the apical limit of the root filling. If the root canal is not measured properly, it may lead to undesirable consequences, and finally, to endodontic treatment failure [1]. A conventional method of root canal length measurement is a film-based radiograph. The fastest currently available dental films are Ektaspeed (E-speed) and Insight (F-speed) films [2]. The problems of conventional radiography in endodontics include the time needed for processing radiographs, and the radiation exposure of the patient [3]. Digital radiography has, to a great extent, overcome the above mentioned problems; in addition, adjusting the image density and contrast is possible in digital radiography in order to improve the visual characteristics of images [4,5]. Furthermore, measurement devices (millimeter rulers) allow accurate measurement of radiographs; and the zooming application can enlarge the tooth apex area [6]. Digital imaging sensors have different technologies. Today, the most practical technologies are Charge Coupled Devices (CCDs) and Photostimulable Phosphor Plates (PSPs). A side from the above mentioned advantages, there are also some disadvantages of digital radiography; for instance, its resolution is lower compared to conventional radiographs. The installation cost of the digital system is also fairly high. Moreover, digital sensors are sensitive, and replacement is expensive. Generally, due to the excellent image quality and the relatively low price of the conventional film they can very well compete with their digital alternative [3]. In view of the advantages and disadvantages of conventional and digital radiography systems, the present work compared E-speed film (Ektaspeed,Eastman-Kodak Co. Rochester, NY, USA) and F-speed film (Insight,Eastman-Kodak Co. Rochester, NY, USA) and PSP sensore (Soredex, Helsinki, Finland) and CCD sensore (RVG, Trophy,NY,USA) in terms of accuracy in the measurement of the root canal length.

MATERIAL AND METHOD

To conduct this study, 35 extracted maxillary single rooted teeth were collected and stored in 0.5 % hypochlorite solution, and fully cleaned from debris; then, they were immersed in distilled water for 24 h . The teeth with open apices or calcifications were excluded from the study [7]. Each tooth was then accessed with a#1557 tapered carbide bur (S.S White Dental Products, Rio de Janeiro, Brazil). Next , each tooth was randomly given a number from 1 to 35, and all the teeth were coded. The cusp tip or the incisal edge in each tooth was considered as the reference point, and a number 10#K- file (Dentsply, Maillefer, Ballaigues, Switzerland) was introducted into the canal until its tip was visible at the apical foramen. After the rubber stop was adjusted to the chosen reference point, the file was removed and the actual length (gold standard) was measured with a ruler (Faber-Castell, Sydney, Australia) and recorded on separate checklists provided for each coded tooth. Conventional and digital radiographs, were obtained using the Minray intraoral X ray unit (Soredex, Helsinki, Finland) with exposure settings of 7 mA and 60kVp. The exposure time was set at 0.25 s and 0.06 s for the conventional and digital radiography, respectively. Before exposure, the teeth were separately placed in the relevant sockets in the maxilla of a dry skull, and fixed with red wax inside the sockets. Then, 8 layers of red wax were put on the maxilla to mimic the soft tissues. E-speed film (Ektaspeed, Eastman-Kodak Co. Rochester, NY, USA) and F-speed film (Insight, Eastman-Kodak Co. Rochester, NY, USA) were used for taking conventional radiographs. All the films were

processed with the HOPE Automatic Processor (HOPE, Washington, USA) under constant conditions of temperature and time. Then, all radiographs were located in the previously numbered frames. The PSP (Soredex, Helsinki, Finland) and the CCD (RVG, Trophy, NY, USA) sensors were used for digital radiography. The radiographs made with the PSP and CCD sensors were numbered and saved with the Digora for Windows (DFW) and SOPRO Imaging software programs, respectively. In the next stage, two radiologist observers were asked to separately measure and record each tooth's root canal length on the checklist. With regard to conventional radiography, this measurement was performed with a ruler (Faber-Castell, Sydney, Australia) and on a negatoscope in a semi-dark room under constant observational conditions. With regard to digital radiography, the digital ruler in each of these software programs was used to measure the root canal length. The observers were allowed to provide the best observation conditions by adjusting the contrast and density of the images. Two weeks later, each observer again obtained conventional and digital radiography under the same conditions as before and measured and recorded the root canal length of each tooth in the form. The data acquired from both radiograpic methods were entered SPSS-19 software (SPSS Inc., Chicago, IL, USA), and analyzed with the ANOVA and Tukey's test.

RESULTS

To assess the reliability of the observations, the intra- and inter-class correlation coefficients were used. The findings showed that there was a high degree of correlation among the observers and different repetitions (above 0.9), which improved the accuracy of the present study. Table 1 presents the mean differences in the root canal length measured by the two observers, as well as, in different repetitions; also, the standard deviation of these sizes based on the gold standard (the root canal length measured with the file) is shown in Table 1.

To determine the accuracy of the different radiographic methods, the results were compared with the gold standard, and the differences were separately examined by the one-way ANOVA . The results did not reveal any significant statistical difference between the different radiographic methods, as well as, in different repetitions ($P > 0.05$). Nevertheless, compared with the gold standard, the conventional F-speed

Table 1 - The mean of the differences in the root canal length measured by two observers based on the gold standard, as well as, in different repetitions, and the standard deviation of these sizes

The system used	First observer in the first repetition		First observer in the second repetition		Second observer in the first repetition		Second observer in the second repetition	
	M	SD	M	SD	M	SD	M	SD
Conventional radiography with F-speed film	-0.8357	1.73940	-0.8500	1.75336	-0.9929	1.8475	-1.0071	1.82958
Conventional radiography with E-speed film	-0.9214	2.03532	-0.9214	2/0786	-0.7643	2.2173	-0.7929	2.26099
PSP*	-0.7586	1.73555	-0.7643	1.73593	-0.9300	1.86793	-	1.87225
CCD**	-1.718	2.40637	-1.784	2.40775	-1.785	2.64665	-1.767	2.64683

* Photostimulable Phosphor Plates
**Charge Coupled Devices

and the CCD digital radiography systems in all cases had the highest and the lowest accuracy, respectively. Also, the PSP and the conventional E-speed radiography systems ranked the second and the thirds, respectively (Table 2).

Table 2 - The accuracy of the different radiographic systems compared with the gold standard

Radiographic system	The Correlation coefficient	P-value
Conventional radiography with F-speed film	0.780	0.000
Conventional radiography with E-speed film	0.674	0.000
PSP*	0.776	0.000
CCD**	0.509	0.001

* Photostimulable Phosphor Plates
**Charge Coupled Devices

DISCUSSION

Accurate measurement of the root canal length is an important root canal treatment, and any error at this stage may lead to endodontic treatment failure [1]. Radiography is recognized as the most reliable technique for measurement of the root canal length and assessment of the quality of root canal filling. Digital radiography, due to its advantages, has nowadays become an established method in dentistry [5]. In this study, the conventional E/F-speed and the PSP/CCD digital intraoral radiography systems were compared for root canal length measurement. In the current study neither of the conventional and digital radiography systems showed a significant difference with the gold standard (the actual root canal length measured with the file) (table 2). Radiography is a suitable and reliable method for root canal length measurement in endodontic treatment. On the other hand, in comparison with the gold standard, in all cases, the F-speed conventional radiography was found to have the highest accuracy. The F-speed film is the fastest intraoral x-ray film, which requires 75 % of the E-speed film exposure and thus reduce the radiation dose of the patient without damaging the quality of the image in terms of resolution, scope and contrast [3,8]. In all cases, the CCD digital radiography, compared with the gold standard, had the lowest accuracy, which can be attributed to the CCD sensor's strong structure and the cable which makes it difficult to place the sensor, and might result in the dimensional distortion of the image, and compromise root canal measurement. According to the study results, the PSP radiography and the E-speed film conventional radiography ranked second and third in term of accuracy,respectively (Table 2). The PSP digital sensor is nowadays very common due to its simplicity, and convenience for the patient. The E-speed film is considered the most commonly used conventional film. Our study showed that the two systems did not differ in terms of their accuracy in root canal length measurement.

Two observers evaluated the radiographs in this study. The results indicated that the correlation between the observers and between different repetitions was very high, which improved the accuracy of study. The current study results were similar to those of previous studies; though there were some differences in the results caused by different methods. Studies by Farida et al. [9] and by Ravi et al. [10] like our study, did not reveal any significant difference between the conventional and digital radiography systems. The current study yielded results similar to those of a study by Mohtavipour et al. [11] differing in that Mohtavipour used teeth with different degrees of root curvature, whereas only teeth with straight roots were used in the current study. Our study results were also similar to those of Lamus et al. [12] In their study, only the E-speed film was compared with one type of digital radiography system; while in the current study the E/F-speed conventional image receptors were compared with two types of digital radiography systems (CCD, PSP). The results of our study were also similar to those of Mentes et al. [13] In their study, no significant difference

was found between the conventional and digital radiography systems; however, they concluded that the root canal length is overestimated in both radiographic systems; whereas our study did not point to a significant difference in the radiographic measurement of the actual root canal length. Lozano et al. [14] also concluded that conventional radiography is the preferred method for root canal length measurement, and digital radiography enjoys an acceptable level of accuracy only when file #15 is used; while our study did not show any difference between the two radiographic systems. Athar et al. [15] concluded that wireless digital sensor may be preferable to wired sensor, in our study also, the wired CCD digital sensor had the lowest accuracy. Akdnize et al. [16] held belief that if digital images are enhanced, they will have the highest accuracy. Also, Radel et al. [17] stressed that the contrast enhancement of digital images improve the measuring accuracy. However, Woolhiser et al. [18] did not find a significant difference between the enhanced/non-enhanced digital and conventional radiography. Although enhancing digital radiographs was not a direct aim of the current study, the observers were allowed to enhance and adjust the image contrast and density to render them visually acceptable. Nevertheless, no significant differences were observed between the conventional and digital radiographs. Brito et al. [19] also found no difference between the radiography method and a direct measurement.

CONCLUSION

Overall, the results of the current study indicated that there was no statistically significant difference between conventional and digital radiography in root canal length measurement; therefore, it can be inferred that the use of digital imaging technique, compared with the conventional technique, does not improve the accuracy of the measurement of the root canal length. but the digital technique has advantages,such as the reduced patient exposure, eliminating the time consuming processing stages, and producing fast images.

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