

Comparing the Accuracy in Diagnosing Periapical Lesions by Conventional and Direct Digital Radiography

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ABSTRACT

This study investigated the accuracy of diagnosing periapical lesions through conventional radiography (CR) and direct digital radiography (DDR) technique. A total of 170 patients with clinically suspected periapical pathosis and 30 normal subjects were included in the study. Both the conventional and digital images were taken with same exposure parameters keeping the film without lead foil and sensor simultaneously, to standardize the images. One endodontist and two oral radiologists evaluated all conventional and digital images and gave their final diagnosis for each technique separately. The diagnostic accuracy of each observer and image mode was calculated as the areas under receiver operating characteristic (ROC) curves. The mean values were statistically compared with the Wilcoxon's signed rank test. In results, the intraobserver variation and interobserver variation were high with conventional radiographic technique in diagnosing initial periapical lesions. There was a slight increase in the mean values for digital technique and in the accuracy of diagnosing the periapical lesions but using wilcoxon signed rank test the z-value was 1.367 and p-value was 0.172. The results of this study suggest that for the diagnosis of initial periradicular pathosis, the difference between the conventional and Trophy RVG 5000 DDR systems is insignificant. However, some advantages like elimination of chemical processing, immediate observation of radiographic images, ability to enhance images, and data storage make DDR preferable in comparison with CR for diagnosis of initial periapical lesions.

Keywords: Periapical lesions, Conventional radiography, Digital radiography.

INTRODUCTION

Conventional radiographs traditionally form the backbone in diagnosis, treatment procedures, and follow-up of periapical lesions. A review of literature suggests that the preoperative presence vs absence of periapical pathology is one of the major indicators of postoperative healing or failure.¹ Initial periapical lesions are difficult to diagnose accurately due to diffuse and infiltrative nature of inflammatory process in bone.² There is a great controversy regarding accuracy of imaging technique in diagnosing periapical lesions. Large numbers of studies have been published for comparing the accuracy of diagnosing periapical lesions through conventional and direct digital radiographic technique.³⁻⁸ However, most of the studies are *in vitro*, only few *in vivo* studies have compared periapical lesions through CR and DDR.

AIMS AND OBJECTIVES

The aim of the study was to compare the accuracy for diagnosing periapical lesions by Conventional and Direct Digital Radiography.

MATERIALS

A total number of 200 patients were selected from the OPD of Department of Oral Medicine and Radiology and provided with a written informed consent, which explains the aims and

methodology of study. The approval from the ethical committee of the institution was obtained regarding the research.

SELECTION CRITERIA

Only mandibular first molars with caries were selected for the study. The two groups were divided as, Group 1 involving carious tooth with tenderness, high quality diagnostic radiographs, teeth with fully formed root apices, and subjects with previous history of dental pain, grossly carious teeth, orofacial pain other than odontogenic pain, large periapical radiolucent lesions, and root canal treated tooth were excluded from the study. In Group 2 the patient without periapical lesion with carious mandibular first molars, subjects with no history of pain, no tenderness, teeth with no previous history of endodontic treatment, tooth with fully formed root apices and high quality diagnostic radiographs were included in study, and the subjects with tender tooth with any systemic condition, which could affect the sign of tenderness, were excluded from the study.

Armamentarium for radiographic analysis was X-ray machine with the setting of 70 kVp, 8 mA and 0.8 second of exposure time with Kodak Ekta speed intraoral radiographic film. The RVG 5000 Super CMOS sensor for digital radiography with Trophy Software and Compaq Presario V2000 laptop with screen resolution of 1280 × 780 pixels was selected for the study, with plastic covering sheet, transparent film packets, lighted view box was there.

METHODS

The present study employed bisecting angle technique for acquiring DDR and CR image because of its preference over paralleling angle technique to detect periapical lesions.^{10,11} The lead foil of the film was taken out in the dark room, and the film and digital sensor were kept together in elastic covering which served three purposes:

1. Exposure to less radiation, as both the images were taken simultaneously in a single exposure.
2. No movement of film and sensor, as the film and sensor were attached together.
3. Standardized outcome of both CR and DDR, as same exposure parameters were used for both the techniques.

All radiographs were taken by the examinee. The conventional films were processed manually with Kodak X-ray developing and fixing chemicals (Kodak India Ltd.). The volume of the developing tank was 13.5 and it was placed in a thermostatically controlled bath containing circulating water. The films of each manufacturer were from the same batch. The processed radiographs were mounted in transparent frames. They were examined using a viewing box with constant light intensity. The digital radiographs were taken by Kodak 5000 digital sensor, keeping it with the film and stored in a computer without any manipulation and enhancement of the image. The conventional radiographs were kept in the transparent sheets. Fixed settings were used for DDR, because improperly used ‘‘enhancements’’ would decrease diagnostic performance.¹¹ As per Kullendorff et al¹² image, processing did not improve the observer’s performance in diagnosing periapical lesions. Fixed settings gave an equal chance of comparable performance to those observers who are less experienced with digital format images. The stored images of CR and DDR were allocated a number and shown to three different observers (two oral and maxillofacial radiologist and one endodontist).

The criteria of diagnosing the absence or presence of lesion was same for each observer as described by IB Benderand Seltzer.^{13,14} The default digital image was presented to the observers. The readings were made with standardized viewing conditions of subdued light. The observer to screen distance was about 60 cm. The images were presented in random order irrespective of presence or absence of lesions. Observers were asked to indicate on a 3 point rating scale.

- a. Lesion absent
- b. Not sure or cannot interpret the radiograph.
- c. Lesion present.

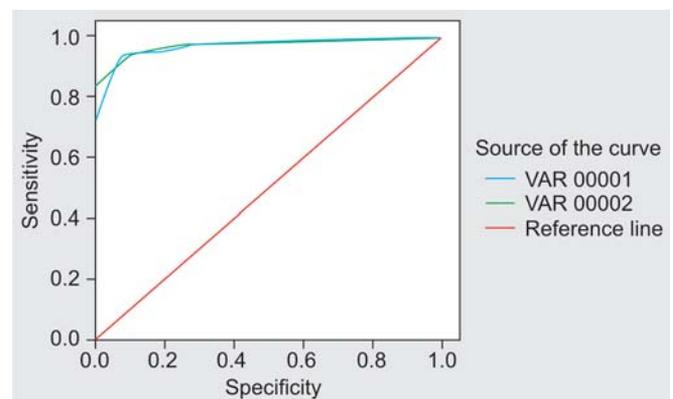
The standard diagnosis was made by the examinees based on clinical findings, conventional radiograph and digital radiograph. This standard diagnosis served as gold standard for the study as described by MB Saunders et al.¹⁵ A consensus decision was reached by negotiation of disagreements. A set of 8 digital images were presented on laptop monitor, and a set of 8 conventional radiographs were kept in a transparent sheet to minimize bias that an observer might have towards one type of imaging technique in preference to another.¹⁵

RESULTS

The deviation between the first and second observations was minimum with observer A followed by observer C, and deviation

was found more in Observer B (Table 1). The intraobserver reliability was more for digital radiographic technique (mean 0.6780 ± 0.068) while it was comparatively less through conventional technique (mean 0.4724 ± 0.106). The kappa value was high with DDR (0.658), suggesting that the observers were more consistent with DDR when observing same DDR image at two different times. Karl Pierson’s Correlation coefficient test was performed each observer for each time with respect to the standard accurate values. Higher the value of correlation indicated more closeness of the observations to accuracy. A significant increase in the accuracy among observers was observed (Table 2) with both techniques in second observation. Hence, the accuracy of diagnosing the presence or absence of lesion was significantly increased when each observer evaluated the same image second time. The sensitivity and specificity of both the techniques was high, however there is still a slight difference between both the techniques regarding the sensitivity and specificity (Table 3). The value of the probability of accuracy was measured by Receiver Operating Characteristic Curve and these were obtained using SPSS software (Appache Software Foundation, USA). The values of P (A) are given in Table 4. The P (A) value is the area under a ROC curve where points representing the true-positive fraction (sensitivity) and false-positive fraction (specificity) are plotted on linear probability scales. The AZ value represents the area under a straight ROC graph plotted on a binormal scale. The P (A) values were calculated for each observer and each imaging technique (Graph 1).

The area under the curve shows slightly more area with the digital technique, but almost both the lines overlap each other, which signifies that there is not much difference in diagnosing periapical lesions through digital and conventional radiographic techniques. The mean of six values for conventional radiographic



Graph 1: ROC curve showing the area under curve as the accuracy for both DDR (VAR00001) and CR (VAR00002)

Table 1: Sum of the square of difference between first and second observations by each observer for each technique

	Sum of the square of deviation with CR	Sum of the square of deviation with DDR
Observer A	95	41
Observer B	154	116
Observer C	86	54

Table 2: Karl Pierson's correlation coefficient test to assess level of accuracy of observation of each observer for each technique

Observers	Conventional technique		Digital technique	
	1st observation	2nd observation	1st observation	2nd observation
Observer A	0.5633	0.6155	0.5726	0.7201
Observer B	0.3586	0.5680	0.4365	0.7657
Observer C	0.5122	0.6626	0.7303	0.7650
Mean	0.5467 ± 0.105		0.6650 ± 0.132	

technique and direct digital radiographic technique was calculated, in which there is a slight increase in the mean value for DDR in the accuracy of diagnosing the periapical lesions as seen in Graph 1, but using Wilcoxon's signed rank test the Z-value was 1.367 and P-value 0.174. These values suggest that statically there is no significant difference found between the accuracy for diagnosing periapical lesions through DDR and CR.

DISCUSSION

The present study was carried out to compare the diagnostic efficacy of DDR and CR for detecting initial periapical lesions. Our results for intraobserver reliability are in accordance with *in vitro* studies conducted by Wallace and James et al,¹⁷ Chandler and Goga et al.¹⁸ and an *in vivo* study by Richard et al¹⁹ in 2000, in which they also found high intraobserver reliability while observing periapical lesions. This correlation could be attributed to the fact, that in both studies the observers had a long experience of diagnosing periapical lesions through both conventional and digital technique. The interobserver reliability calculated by kappa shows higher interobserver agreement through DDR as compared to CR. Interobserver agreement varied between 0.3 and 0.5 for conventional radiography, and 0.6 and 0.7 for digital radiography and approximated to fair to good reliability. Tirrell et al²⁰ found very high interobserver agreement of 85.6% because he included small as well as large periapical lesions of different sizes, which were very easy to detect by observers with any technique.

The present study determined the percentage of correct diagnosis, sensitivity, specificity, and the reliability of periapical radiographic diagnosis for periapical lesions through conventional and digital technique (Table 3). The results were in accordance with *in vitro* studies carried out by Tirrell et al²⁰ and Yokota et al.⁵ According to them, CR was more accurate in identifying specimens without a lesion as compared to DDR, thus making CR more specific. The results of our study support most of the *in vitro* studies regarding specificity and sensitivity.^{5,8,20-22} The present analysis also shows that DDR tends to be more sensitive and CR tends to be more specific for the diagnosis of initial periapical lesions. Conventional radiography tends to be more accurate in assessing normal tooth or the absence of the lesion, whereas

Table 3: Sensitivity, specificity and positive/negative predictive values through CR and DDR

	CR	DDR
Sensitivity	0.7316	0.8972
Specificity	0.9227	0.7926
Positive predictive value	0.9735	0.9437
Negative predictive value	0.4699	0.6655

radiovisiography was more accurate in the smallest lesion condition or in assessing the presence of lesions.

The diagnostic accuracy was evaluated with the receiver operating characteristic (ROC) analysis technique. The graph generated by the ROC curve calculates the P (A) values for each observer and the mean of all P (A) values, which it serves as the value of accuracy for each technique in diagnosing the periapical lesion. Our results were in support of an *in vivo* study by Kullendorff et al¹³ where ROC curve was used to check the diagnostic accuracy of the different techniques. The overall P (A) value was also found very close to our values. However, Wilcoxon's signed rank test values were different in our study. This might be because sample size was more in our study in comparison to the study by Kullendorff et al.¹²

In the present study of the P (A), values generated by ROC curve were compared in the pairwise testing. In the pairwise testing, DDR were slightly better than CR except with one observer in which the P (A) values were greater for CR as seen in Table 5. The results showed no significant differences between the Kodak RVG 5000 DDR system and the E-speed film in diagnosing initial periapical lesions. In contrast to our study, in the study by Dagenais and Clark,²³ observers were unfamiliar with the task of making decisions from digital images, which would result in some underestimation of the DDR. The findings of a study in which DDR systems and film were compared for endodontic length determination, indicated that observers familiar with digital systems were more accurate with digital systems, and observers familiar with film did better with film.²⁴

Most of the studies reported in literature are *in vitro* studies as compared to *in vivo* studies.^{12,20,25} Studies, which conclude that DDR is better than CR for detection of periapical lesions are mostly followed in *in vitro* methods. The lesions in *in vitro* studies^{3-5,7,26} are created by a round bur or by placing acid, which do not accurately recreate the anatomical shapes of inflammatory periapical lesions. The burs often can create an image of a lesion with a well-defined round outline, possibly making detection of lesion an easier task relative to the same task in a clinical situation, like bone loss which would be more diffuse and difficult to detect.

In contrast to our study, Tirrell et al²⁰ concluded that digital technique was more diagnostic for initial periapical lesions. In this study, author created lesions with the help of percholic acid. The time difference between formation of initial lesion and large or late lesion was 12 hours. The mechanism for bone loss in periapical pathosis and bone loss through acid are two completely different processes, and hence the results are incomparable. The results of the present study support those prior studies of Holtzmann et al²⁷ and Mistak et al,²⁸ wherein no differences in

Table 4: Value of the probability of accuracy was measured by Receiver Operating Characteristic Curve obtained using SPSS software

Observers	Conventional technique		Digital technique	
	1st observation	2nd observation	1st observation	2nd observation
Observer A	0.839	0.874	0.800	0.884
Observer B	0.724	0.846	0.760	0.918
Observer C	0.817	0.896	0.889	0.897
Mean	0.8327 ± 0.597		0.8580 ± 0.6281	

Table 5: Mean value of CR and DDR for detecting periapical lesions null hypothesis: true area = 0.5

Test result variable(s)	Area	Std. error (a)	Area under the curve	
			Asymptotic 95% confidence interval	
			Lower bound	Upper bound
VAR00001 (DDR)	0.970	0.011	0.948	0.991
VAR00002 (CR)	0.971	0.010	0.951	0.992

diagnostic accuracy between CR and DDR techniques were found in diagnosing periapical lesions through DDR and CR.

The variability associated with reading and interpreting radiographic images is the important factor contributing to the diagnostic accuracy of identifying bony lesions. Although the intraobserver agreement was fair in our study, however all the observers were closer to the gold standard in their second observation. No matter how great an effort is made to randomize the images presented, there is a certain amount of learning that occurs during each observation. As a result, an image can be retained in the observer's memory and compared with images that are subsequently viewed.²⁹ However, it is likely to occur among all observers as a result of the nature of the process, and thus may not necessarily affect the overall results. In order to obtain reasonably unbiased estimates of periapical radiographic diagnostic performance for periapical lesions, our study meticulously followed the methodology described by Bohay and Richard et al.¹⁹ In an ideal situation, the gold standard or true status of the patient, would be determined with microscopic verification of healthy or diseased periapical tissues. Obviously, this is not feasible in a clinical study, and therefore the results of this study are subject to a misclassification bias. Although the design of this study cannot entirely eliminate the risk of this bias, the method of sampling and the use of the entire clinical and radiographic record in the determination of the "true" periapical status should minimize it. The present study found that CMOS based images were clinically equal to Ektaspeed Plus film radiographs in the diagnosis of periapical lesions. As advances and innovations occur with digital imaging, more *in vivo* studies will be needed to make accurate comparisons of new imaging technologies.

CONCLUSION

The diagnostic accuracy of digital images and conventional radiographs were compared and it was noted that digital images had the highest diagnostic value according to the sensitivity. However, digital imaging is not superior to film based radiographs in the initial depiction of periapical bone lesions. The magnitude of the methodological error of each radiographic method limits

the amount of real change in disease status. More clinical studies are needed to determine the relative diagnostic efficacy of these imaging modalities, with respect to detection of periapical lesions.

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