

Endodontic Radiography: Who Is Reading the Digital Radiograph?

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Abstract

Introduction: Digital radiographic imaging systems have undergone tremendous improvements since their introduction. Advantages of digital radiographs over conventional films include lower radiation doses compared with conventional films, instantaneous images, archiving and sharing images easily, and manipulation of several radiographic properties that might help in diagnosis. **Methods:** A total of 6 observers including 2 endodontic residents, 3 endodontists, and 1 oral radiologist evaluated 150 molar digital periapical radiographs to determine which of the following conditions existed: normal periapical tissue, widened periodontal ligament, or presence of periapical radiolucency. The evaluators had full control over the radiograph's parameters of the Planmeca Dimaxis software program. All images were viewed on the same computer monitor with ideal viewing conditions. The same 6 observers evaluated the same 150 digital images 3 months later. The data were analyzed to determine how well the evaluators agreed with each other (interobserver agreement) for 2 rounds of observations and with themselves (intraobserver agreement). **Results:** Fleiss kappa statistical analysis was used to measure the level of agreement among multiple raters. The overall Fleiss kappa value for interobserver agreement for the first round of interpretation was 0.34 ($P < .001$). The overall Fleiss kappa value for interobserver agreement for the second round of interpretation was 0.35 ($P < .001$). This resulted in fair (0.2–0.4) agreement among the 6 raters at both observation periods. A weighted kappa analysis was used to determine intraobserver agreement, which showed on average a moderate agreement. **Conclusions:** The results indicate that the interpretation of a dental radiograph is subjective, irrespective of whether conventional or digital radiographs are used. The factors that appeared to have the most impact were the years of experience of the examiner and familiarity of the operator with a given digital system. (*J Endod* 2011;37:919–921)

Key Words

Digital radiograph, Dimaxis, Planmeca, radiograph, radiograph interpretation, reading radiographs

Interpretation of the radiograph is a critical tool to determine the presence or absence of periradicular pathosis. Bender and Seltzer (1) and Slowey (2) have shown that bony lesions can only be visualized on radiographs if there is sufficient destruction of the cortical bone by either internal or external etiologic factors. Direct digital radiography was introduced more than 20 years ago. The advantages of this technology over conventional radiographs include lower radiation dosage to capture the image, image that is immediately available for interpretation, ability to archive images, images that are easily shared, and a computer program that allows manipulation of several radiographic properties such as contrast, brightness, and sharpness (3). Since its introduction, the use of digital radiography has increased because the technology has improved and cost has decreased. Some studies (4, 5) have shown that digital radiographs are as accurate as conventional radiographs in detecting periapical lesions. One study (6) compared the accuracy of several digital systems in detecting periapical lesions and found no significant differences between the various systems. Recently, digital images were compared with D-speed radiographs for the detection of artificial bone lesions, and it was concluded that the digital images were significantly better in detecting the artificial lesions (7). To date, no one has reported how well clinicians are able to accurately detect periradicular radiolucencies on digital radiographs.

In 2009 (8) more than 70% of endodontists reported that they were using a digital radiography system, but has this new technology improved the clinician's ability to interpret the image and make a proper diagnosis? According to Goldman et al (9), we do not read radiographs; we interpret them. They reported that the interpretation could be influenced by a variety of factors and variables. The variables included the training and experience of the examiner, the conditions under which the radiograph was viewed, and the type and settings of the x-ray system used to take the radiograph. If the interpretation is not correct, then the diagnosis could be incorrect. This study also reported a relatively low interobserver and intraobserver reliability when interpreting conventional radiographs. Because there have been no reports concerning a clinician's ability to accurately detect periradicular radiolucencies on digital images, this study was designed to determine the interobserver and intraobserver reliability in detecting periradicular radiolucencies by using a digital radiograph system.

Materials and Methods

One hundred fifty digital images of maxillary and mandibular first molars taken with the Planmeca Dimaxis system (PLANMECA U.S.A. Inc, Roselle, IL; Version 3.3.0) were selected for observation. These radiographs were taken by residents and faculty

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members in the Postgraduate Endodontic Clinic at University of Medicine and Dentistry of New Jersey between 2005 and 2010 and were used during the diagnostic and endodontic treatment planning phases of treatment for each case. Two of the authors (S.T., J.L.) selected 150 molar periapical images, out of which they determined 50 images to exhibit normal periapical bone, periodontal ligament (PDL), and lamina dura, 50 with defined periapical radiolucency, and 50 with a widened PDL space. Three endodontists with 5–40 years of experience, 1 oral and maxillofacial radiologist, and 2 endodontic second-year residents independently evaluated the 150 molar periapical radiographs and recorded their findings as 1 of the 3 classifications noted above.

All observers viewed the radiographs under the same ideal lighting conditions on the same computer. The evaluators were allowed to use any or all of the image enhancement tools available on the Planmeca Dimaxis software program when viewing the images. These enhancements included control over the contrast, sharpness, size, black to white, colorization, and brightness of each image. Each viewer was asked to determine whether they interpreted the image to exhibit periapical radiolucency, normal periapical tissue, or a widened PDL space. The same 6 observers then repeated the process with the same 150 molar periapical radiographs 3 months later. The first round of observations determined how well the observers agreed with each other. The second round of observations was used to determine how well they agreed with each other again. The 2 rounds of observations were used in a separate analysis to determine intraobserver agreement. The Fleiss kappa statistical analysis, which is used to measure the level of agreement among multiple raters, was used to determine the interobserver agreement during the first and second rounds of interpretations. Weighted kappa statistical analysis was used to determine the intraobserver agreement between the 2 observation sets.

Results

The overall Fleiss kappa for the 6 observers during the first round of interpretation was 0.34 ($P < .001$). The overall Fleiss kappa for the 6 observers during the second round of interpretation was 0.35 ($P < .001$). This was in the fair range (0.2–0.4) of agreement for the 6 observers at both interpretation times (Table 1). The percentage of agreement among all 6 observers for all radiographs was less than 25%. The percentage of agreement for 5 of 6 observers was approximately 50%.

Weighted kappa statistical analysis was used to measure the level of agreement between the 2 ratings for each observer (Tables 2 and 3). An average weighted kappa value of 0.5 was found, showing a moderate level of intraobserver agreement overall.

Discussion

Despite the many technological advancements that have occurred in dentistry during the last few years, interpreting the radiograph or digital image continues to be more of a subjective exercise than an objective one. Every attempt was made in the present study to limit the variables to the image enhancement tools available in the software for this digital system. Each observer viewed the images on the same

TABLE 1. Fleiss Kappa Statistical Analysis Ranges

Kappa value	Degree of agreement
≤0	Poor
0.0–0.2	Slight
0.2–0.4	Fair
0.4–0.6	Moderate
0.6–0.8	Substantial
0.8–1.0	Almost perfect

computer monitor in the same room with the same lighting. Despite these efforts, the results indicated that the observer interpretation of the digital image radiographs in this study lacked the accuracy, precision, and consistency that one would expect from a group of highly trained and experienced practitioners.

The overall Fleiss kappa for the 6 observers during the first round of interpretation was 0.34 ($P < .001$), and it was 0.35 ($P < .001$) for the second round of interpretation. This was in the fair range (0.2–0.4) of agreement for the 6 observers at both interpretation times. The percentage of agreement among all 6 observers for all radiographs was less than 25%. The percentage of agreement for 5 of 6 observers was approximately 50%. The studies by Goldman et al (9, 10) with conventional radiographs found that the interobserver agreement between their 6 examiners was 47%, and 5 of 6 observers was 67%. Whereas one would expect to see a very good or good degree of agreement with the Fleiss kappa analysis and would even settle for a moderate level of agreement, the fair result achieved by our examiners demonstrates that they could not agree with each other often enough to provide consistent and reliable results.

In the present digital image study the intraobserver reliability ranged from 41%–85%, with an average of only 68% for the 6 examiners. This was only in the fair range for both the first and second evaluations. If the one outlier who agreed with himself only 41% of the time is removed, the range is then 65%–85%. This corresponds with the 74%–80% agreement achieved with conventional radiographs (9, 10). The weighted kappa analysis resulted in an average of 0.5, indicating that a moderate level of agreement was achieved in the current digital image study.

Not only did our examiners have a difficult time agreeing with each other, they were also unable to consistently or reliably agree with themselves. Because the same digital images were to be reexamined by the observers, a 3-month period between observation sessions was chosen in an attempt to limit the recall of the previous interpretations. The same conditions were used for the second viewing as were used at the first evaluation session. Many factors go into how different examiners interpret a radiograph or digital image, but in this study the factor that appeared to have the greatest impact on intraobserver reliability was years of experience. This was an observation that was noted when the results were analyzed, but it was not a factor that was measured either quantitatively or statistically. In general, the more experience an examiner had, the better they were able to agree with themselves. Other factors that might be involved include level of training, education, experience with digital radiographs, and familiarity in manipulating digital radiographs. The observers in this study had a minimum of 1 year of experience with this digital system.

TABLE 2. Weighted Kappa Values for Agreement between 2 Ratings of Each Observer (intraobserver agreement)

	Observer 1	Observer 2	Observer 3	Observer 4	Observer 5	Observer 6
Kappa	0.27	0.60	0.64	0.70	0.11	0.74
Percent agreement	64.6	70.7	77.3	70.7	40.7	84.7

TABLE 3. Weighted Kappa Statistical Analysis Ranges

Kappa value	Degree of agreement
≤0.2	Poor
0.21–0.4	Fair
0.41–0.6	Moderate
0.61–0.8	Good
0.81–1.0	Very good

The development of digital radiographic systems has substantially reduced the radiation exposure to the patient, provided the ability to quickly manipulate and interpret images after exposure, and provided the ability to store, organize, and distribute images by using computers and the Internet (11). The primary objective of dental radiology is to aid in the detection and diagnosis of disease. Our study demonstrates that even with a more advanced digital radiographic image capture system, interpretation remains highly subjective and does not appear to have substantially benefited from this technology. Continual advancements in digital imaging including cone-beam computed tomography might bring us closer to a consensus with regard to the diagnosis of dental pathosis because interpretation of the cone-beam computed tomography image does not depend on the involvement of the cortical-cancellous junction (12).

Conclusion

The results indicate that the interpretation of a dental radiograph is subjective, irrespective of whether conventional or digital radiographs are used. The factors that appeared to have the most impact were the years of experience of the examiner and familiarity of the operator with a given digital system.

Acknowledgments

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