A Comparison of Five Radiographic Systems to D-Speed Film in the Detection of Artificial Bone Lesions

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Abstract
The purpose of this study was to compare three direct digital sensors (Kodak 6100 [Rochester, NY], Schick CDR [Long Island City, NY], and Dexis PerfectSize [Alpharetta, GA]), a phosphor plate system (OpTime; Milwaukee, WI), and F-speed film to standard D-speed film in the detection of artificial bone lesions prepared in mandible bone sections. Artificial bone lesions were prepared at varying depths in the cortical bone. Radiographs were randomly presented to nine different observers. Logistic regression analysis indicated significant differences in lesion detection among the radiographic systems at the mean percentage of cortical bone remaining. The Kodak filtered, Schick filtered, OpTime unfiltered, Schick unfiltered, and Dexis filtered images were significantly better at lesion detection compared with D-speed film. (*J Endod 2008;34:1111–1114*)

Key Words
Artificial bone lesions, comparison lesions, Dexis, D-speed film, intraoral, Kodak, mandible, OpTime, radiographic comparison, radiographic systems, Schick, simulated bone lesions

Radiographs are used to detect periapical changes. The gold standard for many years in dental radiology has been D-speed film. Digital radiographic systems have been introduced that offer many added benefits, among them a more rapid exposure time and an even greater reduction in radiation exposure. Specifically, these digital systems include the direct digital sensors and phosphor plate sensors. Although these digital systems offer advantages, their diagnostic ability to visualize bony changes versus film has been found to be equal to or inferior to standard film in bone lesion detection.

For example, Kullendorff et al. (2) found that conventional film performed slightly better than direct digital radiography in the detection of periapical bone lesions. Also, Wallace et al. (3) found that E-speed film displayed the highest sensitivity and specificity for the detection of simulated periapical lesions followed by phosphor plate and direct digital images. On the other hand, a number of investigators have concluded that there are no significant differences between digital images and conventional film images in the ability to identify periapical bone lesions (4–9). Furthermore, some studies have focused on differences among the digital systems themselves (6, 10). Folk et al. (10) compared two digital systems, the Schick CDR (Long Island City, NY) and Trophy RVGui (Trophy, Marietta, GA), in their ability to detect bone lesions and concluded that there was no significant difference in the accuracy of detecting artificially prepared periapical lesions between the two direct digital systems.

As computer technology has improved, advances have been made in hardware and software. These advances can affect the capturing capabilities and image resolution of digital devices, bringing about a need to examine and compare these changes and analyze their impact clinically. The purpose of this study was to compare three direct digital sensors (Kodak 6100 [Rochester, NY], Schick CDR, and Dexis PerfectSize [Alpharetta, GA]), a phosphor plate system (OpTime; Milwaukee, WI), and F-speed film to standard D-speed film in the detection of artificial bone lesions prepared in mandible bone sections. In addition, filtered and unfiltered images within the three direct digital sensor systems were compared with D-speed film for differences in lesion detection.

Methods and Materials
Seven posterior human mandible sections were collected. The soft tissue was completely removed, and sections were dried. Each section was subjected to a full-length computed tomography scan to measure the width of the buccal and lingual cortical plates.

All sections were luted onto a plastic base. An XCP paralleling device (RINN, Elgin, IL) was used with each mandible section for all radiographs to ensure a reproducible path of the x-ray beam during exposure. An initial buccolingual radiograph of each section was taken before any alterations or preparations in the bone were made. The Gendex GX770 radiographic unit (Lake Zurich, IL) was preset at 70 kVp 7 mA for all images. The exposure time was set at a recommended setting of 0.18 impulses for Kodak’s D-speed film. Kodak’s F-speed film exposure time was set at a recommended setting of 0.10 impulses. The exposure time for the OpTime phosphor plate was set at 0.12 impulses. Soredex does not give recommendations for their OpTime plates. They suggest finding a contrast that is acceptable through trial. The Kodak 6100 sensor was set at 0.05 impulses. Kodak recommends a 0.18 impulse setting for 70 kV and 8 mA and to reduce settings if the images are too dark. All images above 0.05 impulses were too dark for diagnostic purposes in this study. The exposure time for the Dexis PerfectSize (Alpharetta, GA) sensor was set at 0.12 impulses. Dexis recommends between 0.12 and 0.16 impulses and a reading of 2,500 to 3,500 on their radiation gauge, which is found
on their software. The Schick CDR wired sensor (Long Island City, NY) was set at 0.03 impulses. Schick recommends between 0.04 and 0.05 impulses or lower. All impulse settings were determined by starting at the manufacturer recommendations for the mandibular premolar area and by determining the optimum contrast for diagnosis through a pilot study. Traditional films were processed at 81 °F in the Air Techniques AT/2000 automatic processor (Melville, NY).

Simulated bone lesions were created by removing varying depths of cortical bone using a no. 560 low-speed bur. Rubber stoppers were used to control the depth of the cuts. Single-hole cuts of varying depths were made randomly in the buccal plate. A negative control was defined as a circular spot with a permanent marker corresponding to the width of the no. 560 bur without a cut being made. Sequential depth cuts of cortical bone were then removed in random positions on a prearranged grid. The initial depth cut was 0.25 mm, the second was 0.5 mm, and the third was 0.75 mm. Cuts increased in increments of 0.25 mm until 2.0 mm of buccal cortical bone had been removed. A final positive control was made by fully penetrating the buccal and lingual plates. Overall, there were eight sequential depth cuts as well as one negative control and one positive control for each mandible section (Table 1). After completion of the depth cuts, a final radiograph was exposed with each new lesion on the altered images. Positive responses were recorded on a prepared template corresponding to the known location of all lesions for a particular sample with its corresponding depth cuts. Responses were then tabulated on an Excel spreadsheet (Microsoft) (Table 2).

The binary response from the examiners was modeled by using repeated-measures logistic regression procedure (GEE method in SAS PROC GENMOD with and exchangeable covariance structure; SAS Version 9.1, Cary, NC).

**Results**

The probability of lesion detection was calculated at the mean percentage (68.7%) of cortical bone remaining. The Kodak filtered images had the nominally highest probability (0.786) of lesion detection, followed by the Schick filtered images (0.766), OpTime phosphor plate unfiltered images (0.746), Schick unfiltered images (0.758), Dexis filtered images (0.723), Dexis unfiltered images (0.698), Kodak unfiltered images (0.694), F-speed film (0.653), and D-speed film (0.652).

Controlling for specimen and observer differences, a logistic regression indicated that, at the mean percent (68.7%) of cortical bone

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**Figure 1.** Sample Kodak radiographs of original mounted section and after depth cuts (filtered and unfiltered).
remaining, there were significant differences between the various radiographic systems (p = 0.0051). Specifically, a comparison of D-speed film to the other systems revealed that there were significant differences between D-speed film and the Kodak filtered images (p = 0.0001), Schick filtered images (p = 0.0016), OpTime unfiltered images (p = 0.0065), Schick unfiltered images (p = 0.0271), and Dexis filtered images (p = 0.0217). However, there were no statistically significant differences between D-speed film when compared with the Dexis unfiltered images (p = 0.1839), Kodak unfiltered images (p = 0.1585), and F-speed film (p = 0.9755) (Table 3).

Within the four digital systems, in their original software presentation after exposure (ie, Dexis filtered, Kodak filtered, OpTime unfiltered, and Schick unfiltered), there were no significant differences in lesion detection observed (p > 0.27).

A comparison of filtered versus unfiltered images revealed no significant differences in lesion detection between either the Dexis filtered and unfiltered images (p > 0.05) or the Schick filtered and unfiltered images (p > 0.05). However, there were significant differences in lesion detection between the Kodak filtered and unfiltered images (p < 0.0266).

**Discussion**

A number of previous studies have concluded that D-speed film has performed equal to or better than direct digital devices and phosphor plate systems in bony lesion detection (2–9). The probability of lesion detection with digital radiographic systems in our study was significantly greater than lesion detection with D-speed film. Specifically, the Kodak filtered, Schick filtered, OpTime unfiltered, Schick unfiltered, and Dexis filtered images were significantly better at lesion detection compared with D-speed film. The current results may be because of recent advances in sensor, scanner, and software technology and could account for the differences from previous studies. It is unlikely that experience with digital radiography played a role in the current study. Of the nine examiners that participated in the study, six of them use D-speed and F-speed film in their daily practices.

It is also unlikely that our study design for artificial bone lesions interfered with the results. Odontogenic lesions normally initiate around a specific tooth and spread from the cancellous to cortical bone as the lesion expands. In our study design, artificial lesions were prepared in the outer cortex of cadaver bone at varying depths. This experimental design is unlike the normal path of lesion progression in the body. However, previous studies have shown that lesions in cancellous bone are often undetected unless a portion of the cortical bone is affected (11–18). It has also been shown that the amount of mineralized bone affected is more important than the size of the lesion (19). Furthermore, a lesion often has to cause 30% to 60% cortical bone loss to be visualized radiographically (20). Therefore, the authors concluded that lesions prepared in the outer cortex would present in a similar manner radiographically to those prepared from the inner cancellous bone extending toward the cortex. This enabled the authors to perform the current study in a practical method with the ability to more precisely measure the amount of bone removed in the preparation of the simulated lesions.

Comparisons of the filtered and unfiltered images in the digital systems revealed differences between the systems. Kodak filtered images had the greatest probability of lesion detection, whereas unexpectedly unfiltered images showed no significant differences in lesion detection compared with D-speed film. These differences were significant. A possible explanation for this is that the impulse setting in our study differed from Kodak’s recommended setting. Kodak recommends an 0.18 impulse for 70 kV and 8 mA and to reduce settings if the images are too dark. Our impulse setting was set at 3 because all images above 3 impulses were too dark for diagnostic purposes. This may have affected outcomes for this particular sensor. Likewise, the Dexis filtered images were significantly better at lesion detection than D-speed film, whereas unfiltered images showed no significant differences in lesion detection compared with D-speed film. However, these differences were not significant. Both, the Schick filtered and unfiltered images were significantly better at lesion detection when compared with D-speed film. Schick was the only digital system that was significantly better at lesion detection compared with both filtered and unfiltered images compared with D-speed film.

**Acknowledgment**

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**References**

6. Bavazza SB, Geist JR, Pink FE, Hoen MM, Steinman HR. Comparison of diagnostic accuracy of digital imaging by using CCD and CMOS-APS sensors with E-speed film in

**TABLE 2.** Number of Lesions Detected (out of 81) for Each Depth Cut on Each Mandible Section

<table>
<thead>
<tr>
<th>Depth Cuts</th>
<th>Mandible Sections</th>
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<th>3</th>
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<th>6</th>
<th>7</th>
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**TABLE 3.** Predicted Probability of Lesion Detection at the Mean Percentage Bone Loss (68.7%)

<table>
<thead>
<tr>
<th>Predicted</th>
<th>p Value</th>
<th>System</th>
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<tr>
<td>0.786</td>
<td>0.0001</td>
<td>Kodak* (filtered)</td>
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<tr>
<td>0.766</td>
<td>0.0016</td>
<td>Schick (filtered)</td>
</tr>
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<td>0.746</td>
<td>0.0065</td>
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<td>DEXIS (unfiltered)</td>
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<td>0.694</td>
<td>0.1585</td>
<td>Kodak (unfiltered)</td>
</tr>
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<td>0.9753</td>
<td>F-speed</td>
</tr>
<tr>
<td>0.652</td>
<td>0.0016</td>
<td>D-speed</td>
</tr>
</tbody>
</table>

The predicted values are the probability of a positive response at 68.7% bone remaining. The p value is the comparison of each imaging system with D-speed.

*Original filtered/unfiltered presentation on software from the manufacturer.