Radiovisiography for imaging root canals: an in vitro comparison with conventional radiography
A. C. Shearer* / K. Horner** / N. H. F. Wilson*

Radiovisiography is a rapid, low-dose, digital imaging system that utilizes a small, intraoral sensor in place of radiographic film. Because of these characteristics, it may be particularly suitable for use in endodontics. Consequently radiovisiography and conventional film radiography for the imaging of root canals were compared in vitro. There was no statistically significant difference between the percentage of length of root canal visible on conventional film and that visible on radiovisiographic images. Thus, radiovisiography may be considered to be of equal value to conventional film radiography for the imaging of root canal systems in vitro. (Quintessence Int 1990;21:789-794.)

Introduction

The latest alternative to conventional film (CF) for intraoral radiography is radiovisiography (RVG) (Trophy Radiologie), a digital imaging system that utilizes an intraoral sensor in place of radiographic film. Two RVG systems are currently available: the original Model 1 system (Fig 1) and a new Model 2 system (Fig 2). The latter is a more compact system with a capacity for greater image manipulation and can be linked to a computer for image storage and retrieval.

The RVG system

Both systems comprise four main components: an x-ray unit, an intraoral sensor, a display processing unit, and a printer.

X-ray unit. A conventional x-ray generator, fitted with a special electronic timer to give the short, accurately controlled exposure times required, is used. An x-ray unit fitted with this timer can still be used for conventional radiography.

Intraoral sensor. The primary image receptor in the sensor (Fig 3) is a rare-earth intensifying screen (25 x 16 mm) that is housed in a rigid plastic casing (40.6 mm long x 22.8 mm wide x 14 mm thick). When x-rays are incident on the intensifying screen, the resulting fluorescence is conducted by an optical system to a charge-coupled device (CCD). The CCD detects the light pattern and translates it into an electrical signal that is received by the display processing unit. A long, flexible cable carrying the electrical signal from the CCD connects the sensor to the display processing unit.

The sensor cannot be sterilized; therefore during clinical use it is covered by a disposable latex finger sheath. The sensor can be held in the mouth by the patient, by a bite-block attachment, or by one of a range of specially designed sensor-holding beam-aiming devices.

Display processing unit (DPU). This unit houses both the electronic equipment that digitizes, processes, and stores the analog signal from the CCD and the television screen on which the image is displayed. When an exposure is made, an image appears almost immediately on the screen. In both models, the screen...
Fig 1 The Model 1 Radiovisiography system: (a) x-ray set with electronic timer; (b) intraoral sensor; (c) display processing unit; and (d) printer.

Fig 2 The Model 2 Radiovisiography system; (a) separate television monitor showing clinical images; and (b) display processing unit.

Fig 3 The intraoral sensor.

image is a magnification of the primary image on the intensifying screen in the sensor.

The DPU has controls that permit image manipulation. The brightness and contrast controls allow adjustment of the image as with any television set. This image can then be changed in two ways: The gray scale of the image on the screen can be reversed so that black becomes white and vice versa, and the information in the image can be "enhanced" by increasing the contrast while compressing the latitude of the system. The original image remains stored in the unit and can be returned to the screen at any time.

A zoom feature is present on both models. On the original system, a separate exposure is required to produce an enlarged image of the periapical region, corresponding to the apical half of the image receptor surface. On the new system, any of nine areas of the image can be enlarged without the need for a second exposure.

Printer. A separate printer linked to the DPU is used to produce a permanent record of the images on the television screen. In this study, a Dry Silver Imager (3M Dental Products Div) was used. This produces hard copy images similar in appearance to black and white photographic prints. Separate contrast and brightness controls are located on the printer.

The physical evaluations of RVG by Mouyen et al. demonstrated that it is a low-dose, rapid-imaging system but it has lower resolution than conventional dental film. Mouyen et al. suggest, however, that any loss in image sharpness may be overcome by the increased information obtained by the image manipulation facility of RVG.

Horner et al. confirmed these findings and showed that the radiation dose of Model 1 RVG was 41% of that for conventional radiography using E-speed film (Eastman Kodak Co). The limiting resolution of the system was found to be 5 to 6 line pairs per millimeter, and image distortion inherent in the system was minimal and limited to the periphery of the image. Horner et al. also carried out a small clinical trial and concluded that RVG can produce clinically acceptable periapical images (Fig 4). However, they expressed some concern at the large number of images rejected. This was thought to be due to difficulties in accurately positioning the small sensor. The result was that the area of interest was missed from the image in approximately 25% of the examinations. An idiosyncracy of RVG is that the images are displayed in reverse orientation (ie, viewed as though the operator were positioned inside the patient’s mouth looking out).
Despite these problems, RVG may be of particular value in endodontics, for example in imaging root canals and in determination of root length.

The aim of this study was to make an in vitro comparison of radiovisiography and conventional film radiography for the imaging of root canals.

Method and materials

Sixty extracted teeth were used in this study: ten maxillary anterior teeth (incisors and canines); ten mandibular anterior teeth (incisors and canines); ten maxillary premolars; ten mandibular premolars; ten maxillary molars; and ten mandibular molars. Following extraction, all teeth were stored in distilled water until use. Prior to imaging, each tooth was mounted in a 3-cm³ block of the soft tissue equivalent poly(methyl methacrylate).

A 70-kV(p) 8-mA x-ray unit fitted with a cylindrical collimator and the appropriate timer, and linked to a Model 1 RVG system, was used. The exposure times selected for RVG and film were those indicated on the timer for the tooth type. E-speed film No. 2 was used for the conventional film examinations. For both film and RVG techniques, a focus-receptor distance of 22 cm was used.

Each mounted tooth was exposed once using both conventional film and RVG. Films were processed in a sensitometrically monitored automatic film processor.

The presence or absence of a root canal was noted on each image. The length of canal visible from its most apical extent to a line drawn at the level of the cementoenamel junction was measured. This was expressed as a percentage of the distance between the radiographic apex and the cementoenamel line (the “root length”). All images were examined concurrently by two investigators. Conventional films were viewed under standardized conditions. Radiovisiographic images were examined directly from the screen of the DPU. The contrast control on the DPU was set at maximum and the brightness was adjusted to obtain subjectively optimal imaging of the root canals. Radiovisiography was used in both unenhanced and enhanced modes. The degree of enhancement was selected to give the clearest image of the root canal.

Comparisons were made between the conventional film images and the RVG images in both unenhanced and enhanced modes. Differences between the imaging of canals in single and multirooted teeth were also assessed. The results were analyzed using matched-pair $t$ tests.

Results

Examples of radiovisiographic and conventional film images obtained during the study are shown in Figs 6 to 8.

Sixty teeth, comprising 94 root canals, were imaged using conventional film and radiovisiography. The
**Table 1** Comparison of percentage of root canal length visible in all teeth on conventional film (CF), radiovisiographic (RVG), and enhanced radiovisiographic (enRVG) images (n = 94)

<table>
<thead>
<tr>
<th></th>
<th>Mean difference</th>
<th>Standard error</th>
<th>t</th>
<th>Significance</th>
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<tbody>
<tr>
<td>CF vs RVG</td>
<td>1.47</td>
<td>1.11</td>
<td>1.32</td>
<td>NS</td>
</tr>
<tr>
<td>CF vs enRVG</td>
<td>-2.67</td>
<td>1.90</td>
<td>-1.41</td>
<td>NS</td>
</tr>
<tr>
<td>RVG vs enRVG</td>
<td>-4.14</td>
<td>1.60</td>
<td>-2.58</td>
<td>P &lt; .05</td>
</tr>
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NS = not significant.

**Table 2** Comparison of percentage of root canal length visible in single-rooted teeth on conventional film (CF), radiovisiographic (RVG), and enhanced radiovisiographic (enRVG) images (n = 30)

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<thead>
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<th>Mean difference</th>
<th>Standard error</th>
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<th>Significance</th>
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<tbody>
<tr>
<td>CF vs RVG</td>
<td>2.60</td>
<td>1.29</td>
<td>2.01</td>
<td>NS</td>
</tr>
<tr>
<td>CF vs enRVG</td>
<td>1.30</td>
<td>0.93</td>
<td>1.40</td>
<td>NS</td>
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<tr>
<td>RVG vs enRVG</td>
<td>-1.30</td>
<td>0.86</td>
<td>-1.51</td>
<td>NS</td>
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</table>

NS = not significant.

**Table 3** Comparison of percentage root canal length visible in multirooted teeth on conventional film (CF), radiovisiographic (RVG), and enhanced radiovisiographic (enRVG) images (n = 64)

<table>
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<th>Mean difference</th>
<th>Standard error</th>
<th>t</th>
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<tr>
<td>CF vs RVG</td>
<td>0.94</td>
<td>1.52</td>
<td>0.62</td>
<td>NS</td>
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<tr>
<td>CF vs enRVG</td>
<td>-4.53</td>
<td>2.73</td>
<td>-1.66</td>
<td>NS</td>
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<tr>
<td>RVG vs enRVG</td>
<td>-5.47</td>
<td>2.31</td>
<td>-2.37</td>
<td>P &lt; .05</td>
</tr>
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</table>

NS = not significant.
mean differences in percentage of length of root canal visible on the RVG, CF, and enhanced RVG images and the results of the statistical analysis are presented in Table 1. Separate analyses for the canals of single-rooted teeth (n = 30) and canals of multirooted teeth (n = 64) are shown in Tables 2 and 3.

No significant differences were found between CF and RVG or between CF and enhanced RVG for the imaging of percentage of root canal length visible. Enhanced RVG images showed a significantly greater percentage of root canal length than did RVG images for all teeth (P < .05) and for multirooted teeth (P < .05).

Discussion

Clinical endodontics depends heavily on information from radiographs for diagnosis and treatment. Therefore, any advances in radiography may be of interest to dental surgeons who undertake endodontic therapy.

A previous study suggested that radiovisiography may be of particular value for endodontic imaging. The rapid image production and the low dose of radiation are obvious benefits. The small sensor size makes this system particularly appropriate for single-tooth imaging. However, the resolution of RVG has been shown to be inferior to that of conventional film, and it is possible that this may reduce the efficiency of RVG in the imaging of small structures, such as fine root canals in the apical region. Consequently, this in vitro investigation was undertaken to compare RVG and conventional film radiography for the imaging of root canals.

Direct measurement of root canal length was impracticable because of the magnification inherent in RVG images. Therefore, the percentage of visible root canal length was recorded. The latter is in addition to the geometric magnification found in both CF and RVG imaging. No comparisons with actual root canal length of the specimen teeth were made, because this study was undertaken to assess a new imaging system and to compare it with CF imaging, which is the universally accepted method of estimating root canal length for clinical endodontics.

The results revealed no significant differences between CF and RVG or between CF and enhanced RVG for the imaging of root canal length in the samples studied. This suggests that the inferior resolution of RVG may not affect the imaging of root canals. This is in agreement with the findings of Okono et al., who concluded that the use of intensifying screens in cassettes for intraoral radiography would have only a relatively small effect on the precision of endodontic distance measurements.

Clinically, the difference in subject contrast among patients and the variation in quality and quantity of trabecular bone will affect image quality. Consequently, there are limitations in an in vitro study of the type carried out, and, therefore, clinical evaluations of RVG are now indicated to confirm the in vitro findings.

The subjective impression gained during the study was that enhancement of RVG images did not provide extra information but clarified the existing information. Enhancing the RVG image resulted in a statistically significant increase in the percentage of length of root canal visible when all teeth were compared. However, this small increase (mean difference of 4.14%) may be of little relevance clinically. When single-rooted and multirooted teeth were considered separately, the difference between RVG and enhanced RVG was only significant for the multirooted teeth. This reflects the fact that, in the single-rooted teeth, the canal was typically visualized to the apex (i.e., 100% of the root canal was visible), so that enhancement was of little value. However, in a proportion of the multirooted teeth, in which fine root canals were not seen to the apex, the enhancement facility of RVG was of some benefit.

Apart from obvious design changes, the only difference between the Model 1 and Model 2 systems relevant to this study is that a greater degree of enhancement is possible with the new system. This facility may improve imaging with RVG. Further studies are required.

Clinical studies of RVG for use in endodontic imaging are now indicated. Such studies may, however, experience a similar image rejection rate to that found by Horner et al. This may affect the clinical acceptance of radiovisiography by dental surgeons.

Conclusions

Radiovisiography is of equal value to conventional film radiography for the imaging of root canal systems in vitro. However, radiovisiography has the advantage of being a rapid, low-dose imaging technique. Studies are now indicated to assess the RVG system clinically.
Acknowledgments

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References