Comparison of images from digital intraoral receptors and cone beam computed tomography scanning for detection of voids in root canal fillings: an in vitro study using micro-computed tomography as validation

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Objective. To compare the diagnostic value of six intraoral digital receptors and a cone beam computed tomography scanning system for detection of voids in root fillings.

Methods. Sixty-seven root-filled roots with oval and ribbon-shaped canals were included. Three standardized radiographic examinations were performed for each root with six intraoral digital receptors. Further, the roots were examined using CBCT. Four observers measured the extension of voids in all images. The true extension of voids was recorded in cross-sectional images from micro-computed tomography scans (micro-CT). The proportion of voids observed in the radiographic image validated against micro-CT was calculated for each system.

Results. All intraoral receptors underestimated the extension of voids, and few false positives were recorded. CBCT resulted in a higher proportion of correctly observed voids, but with several false-positive recordings.

Conclusions. The diagnostic value differed little among the six intraoral systems. CBCT overestimated in many cases the proportion of voids in root fillings. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013;115:810-818)

Digital intraoral receptors have several advantages compared to conventional film,[1] and recently complementary metal oxide silicon (CMOS)-based sensors have been introduced.[2] Photostimulable phosphor (PSP) plate systems entered dentistry approximately five years after the first sensors. Most PSP systems provide lower spatial resolution than sensor systems.[2] Spatial resolution may influence diagnostic accuracy in subtle diagnostic tasks such as detection of root fractures, for which a high resolution sensor performed more accurately than a PSP system,[3] or in caries diagnostic studies, for which however most studies have found no differences between images with various resolution and receptor type.[4,5]

The quality of root fillings is usually assessed in radiographs. As new receptors are introduced, an evaluation of their performance with respect to specific diagnostic tasks is necessary. In the past, studies have assessed the diagnostic value of charge-coupled device (CCD) sensors in relation to endodontic treatment,[6-9] but no studies have so far assessed CMOS sensors in relation to void detection in radiographic images of teeth with root fillings. The intraoral radiographic image is a result of a compression of three-dimensional (3-D) structures into a two-dimensional view. The tooth and its surrounding tissues are visualized in the mesio-distal plane; studies have, however, shown that important features in the bucco-oral plane may not be revealed.[10] It may not be

Statement of Clinical Relevance

Intraoral receptors underestimate the extension of voids in root canals. However CBCT axial sections overdiagnosis presence of voids, possibly due to artifacts from the gutta-percha root fillings. CBCT cannot be recommended for assessment of quality of root fillings.

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Table I. Product information and characteristics of the six intraoral receptors

Manufacturer	*Name*	*Software*	*Bit depth*	*Exported file format*	*Pixel resolution*	*File (kB)*	*Radiation field (mm)*	*Outer dimensions (mm)*	*Thickness (mm)*	*Thickness at wire (mm)*
Kodak	Kodak RVG 6100	Kodak Dental Software 6.11.5.2	8	tiff	1440 × 1920	8116	27 × 36	32 × 43	7	12
Planmeca	Planmeca ProSensor	Dimaxis Classic Version 4.5.0	8	tiff	864 × 1195	1009	26 × 36	30 × 43	6	12
Sirona	Sidexis XIOS	SIDEXIS neXt Generation 2.4	8	tiff	640 × 912	572	26 × 36	30 × 43	5	10
Instrumentarium	Sigma M	CliniView 8.2.1.1	8	tiff	1358 × 1916	7627	26 × 36	30 × 43	6	12
Soredex	Digora Toto	CliniView 8.2.1.1	8	tiff	1358 × 1916	7627	26 × 36	30 × 43	6	12
Soredex	Digora Optime	CliniView 8.2.1.1	8	bmp	874 × 1164	2964	31 × 41	31 × 41	1	–

possible to detect voids in root fillings in the bucco-oral dimension especially in oval or ribbon-shaped canals that have the widest extension in the bucco-oral direction.[11]

In recent years cone beam computed tomography scanning (CBCT) has become available for dentistry, and the diagnostic value of this 3-dimensional technique is currently under evaluation. In relation to root-filled teeth supplied with posts, CBCT may have the disadvantage that artifacts may be seen as streaks or dark areas in connection with a highly radiopaque material,[12] and a recent study found that fractures in teeth with fiber-resin posts were more accurately detected than in teeth with titanium posts.[13] So far, it has not been studied whether CBCT is more or less accurate than intraoral receptors for detection of voids in roots filled with gutta-percha.

The aim of this study was to compare the diagnostic value of six intraoral digital receptors and a CBCT system for detection of voids in root fillings performed in oval and ribbon-shaped root canals.

MATERIALS AND METHODS

Seventy-five extracted human mandibular molars and premolars were used in the study. The tooth crown was removed just below the cementoenamel junction with a slow-speed diamond disc (Herico, Berlin, Germany) under water-cooling. The inclusion criteria were that the roots should have an oval or ribbon-shaped canal. Six roots were excluded because the root canals were round, and two roots were excluded due to procedural problems. Finally, 67 roots were included in the study. The roots were throughout the study stored in a hydrophor with a 0.2% chlorhexidine solution at room temperature.

The root canals were prepared with crown-down technique using Profile (Dentsply Maillefer, Ballaigues, Switzerland) rotary instruments, size 35, taper 0.04. Throughout instrumentation the root canals were irrigated with 17% Ethylenediaminetetraacetic acid (EDTA) and in between each file procedure flushed with 0.5% NaOCl using a max-i-Probe 30G needle (Dentsply Maillefer, Ballaigues, Switzerland). The oval or ribbon-shaped canals were prepared as two canals in the middle and cervical part of the canals in an attempt to include and prepare narrow fissures and recesses. After instrumentation, EDTA was deposited for 5 min in the canals to remove smear layer and debris followed by a rinse of NaOCl. The roots were then dried with paper points.

The prepared root canals were filled with AH Plus (Dentsply International, York, PA, USA) and either cold lateral compaction technique or a hybrid technique using a gutta-percha master point size 35, 0.04 taper and Thermafil (Dentsply International, York, PA, USA).

Radiographic examination

Six intraoral digital radiography systems were used, including one PSP receptor (New DIGORA Optime, Soredex/PaloDEx group, Tuusula, Finland) and five CMOS sensors (Kodak RVG 6100, Kodak, NY, USA; Planmeca ProSensor, Planmeca, Helsinki, Finland; Sidexis XIOS, Sirona Dental Systems GmbH, Bensheim, Germany; Sigma M, Instrumentarium, Knowsley, UK; Digora Toto, Soredex/PaloDEx group, Tuusula, Finland). The characteristics of each receptor are shown in Table I. The receptors will be named in the text, tables and figures in alphabetic order as follows: Kodak, Optime, Planmeca, Sigma, Sirona, and Toto, respectively.

To mimic the clinic situation the roots were mounted in the best fitting empty alveolus in a dry human skull, and a 0.5-1 cm thick water-balloon was used as soft tissue simulation during exposure. Exposures with intraoral receptors were standardized, using a GX 1000 dental unit (Gendex Corporation, Milwaukee, WI, USA) at 65 kV, 10 mA, exposure time from 0.18-0.30 s depending on root and bone thickness and receptor. The focus-to-object distance was 30 cm, and object-to-film distance was 1 cm. Three exposures were taken for each root with each of the six receptors: one orthogonal exposure (O) and two eccentric exposures with a horizontal angle of 10° mesially (M) and distally (D) to the orthogonal projection. The receptor was placed parallel