SESSION 4: Image Acquisition and Processing

A Comparison of Image Characteristics and Convenience in Panoramic Radiography Using Charge-Coupled Device, Storage Phosphor, and Film Receptors

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This study compared the image layer characteristics, dose requirements, and convenience in use of panoramic radiography using each of four different image receptors including traditional indirect exposure x-ray film, a storage phosphor system, and two solid-state sensors. The OP 100 D (Instrumentarium Imaging, Tuusula, Finland) charge-coupled device (CCD) sensor provided an instant image with a wide focal trough, making patient positioning error unlikely, but at the same time required a patient dose higher than that used with film. While the DigiPan (Trex/Trophy, Marne-la-Vallée, France) CCD significantly reduced the patient dose to radiation and also provided an instant image, the focal trough was narrower making patient positioning error more likely. The storage phosphor system provided high resolution and a reasonable focal trough width, but the procedure took longer than traditional film radiography and did not provide a dose saving.

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PANORAMIC RADIOGRAPHY is used in hospital emergency rooms to evaluate possible mandibular fractures in addition to assessment of urgent dental care needs. As hospitals move to become totally filmless, it is desirable that panoramic images are acquired in digital form. Furthermore, immediate image acquisition is a plus when seeking to diagnose and treat urgent care patients. The objective of this study was to compare the image layer characteristics, dose requirements, and convenience in use of panoramic radiography variously using each of four different image receptors including traditional indirect exposure x-ray film, a storage phosphor system, and two solid-state sensors.

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Fig 1. Instrumentarium OP 100 D. A CCD sensor is standard. The CCD is fixed in place and not interchangeable with a film cassette.

STUDY DESIGN

The systems tested were (1) a prototype OP 100 D (Instrumentarium Imaging, Tuusula, Finland) using a charge-coupled device (CCD) with square pixels having side dimensions of 96 μm (Fig 1); (2) the Trex/Trophy DigiPan (Marne-la-Vallée, France) CCD using a CCD with square 104- μm pixels (Fig 2); (3) the DenOptix storage phosphor system (Dentsply/Gendex, Des Plaines, IL); and (4) Eastman Kodak T-Mat G film with matching Lanex Regular screens (Rochester, NY). The OP 100 panoramic x-ray generator (Instrumentarium Imaging) was used throughout. For the DenOptix

Fig 2. Trophy DigiPan. The CCD replaces the film cassette in an OP 100 panoramic machine.

system, the imaging plate was saturated with greater than 4,000 lux light from a viewbox for 1 minute immediately prior to placement in the cassette and exposure (Fig 3). Following exposure, the DenOptix plate was unpacked in low ambient lighting conditions (<18 lux) and then laser-scanned at 150 dpi. Film radiographs were processed in Kodak Readymatic (Rochester, NY) solutions using an All-Pro Imaging 100 Plus (Hicksville, NY) automatic processor.

Image layer contours were determined at resolution limits of 6.0, 5.0, 4.0, 3.0, and 1.5 line pairs/mm using resolution test patterns: Kyokko Type 1 from Optonix (Kasei, Tokyo, Japan) and Models 07-501 and 07-525 from Nuclear Associates (Carle Place, NY). Each was positioned in turn at intervals along the beam projection paths. The necessary exposures and times from image exposure to display were also investigated.

RESULTS

Spatial Resolution and Focal Trough

The maximum spatial resolution for images made using T-Mat G film with Lanex Regular screens exceeded 5.0 lp/mm film, but did not exceed 6.0 lp/mm (Table 1). The OP 100 D CCD and for the DenOptix storage phosphor system also produced spatial resolutions that exceeded 5.0 lp/mm but did not exceed 6.00 lp/mm. In comparison, the DigiPan CCD achieved 4.37 lp/mm but did not exceed 4.86 lp/mm. Using the 1.5 lp/mm resolution limits, the focal trough limits in the midline were 14 mm for DigiPan, 17 mm for film, 23 mm for DenOptix, and 20 mm for the OP 100 D. In the posterior "dental arch" segment, the focal trough width was 43 mm for DigiPan, 44 mm for film, 65 mm for DenOptix, and 71 mm for the OP 100 D. Representative plans of the respective focal troughs are illustrated in Fig 4.

IP cleared using
viewbox light

IP placed in cassette
(without screens)

Exposed IP placed
in drum scanner for
processing

Fig 3. DenOptix storage phosphor plate for panoramic application.

Table 1. Comparison of Panoramic Modalities

	OP 100 T-Mat G Film	OP 100 DenOptix	OP 100 DigiPan	Prototype OP 100 D
Technology	Analog film	Storage phosphor	CCD	CCD
Maximum resolution (lp/mm)	>5; <6	>5; <6	>4.47; <4.86	>5; <6
Anterior layer width (mm)	17	23	13	20
Posterior layer width (mm)	44	65	43	71
Relative dose	1	1.25	0.3	1.50
Procedure time (min)	4	6	2	2

Time Involved

The CCD devices produced immediate images, and the time for procedure, including entry of "patient" identifying information, was less than 2 minutes. Film images with 90-second automatic processing took approximately 4 minutes per procedure. The DenOptix storage phosphor system took in excess of 6 minutes per procedure because of the relatively long scanning time involved and the need to unpack the exposed storage phosphor plate under subdued lighting.

Radiation Dosage

Using the radiation exposure for film as the baseline, the DigiPan permitted image acquisition with a 70% dose savings, whereas the DenOptix

and OP 100 D both required an increase in exposure over film (Table 1) to attain optimal images.

DISCUSSION

While computed tomography is the method of choice for imaging maxillary fractures, the panoramic radiograph remains a standard method in dentistry, and is state of the art for detection of mandibular fractures. To achieve digital integration of existing panoramic technology, there are several alternatives. Where an instant image is desired, solid-state technology may be considered to have an edge. With CCD-based systems, the image is seen almost instantly on the computer screen. New panoramic machines may be purchased with a CCD option (eg, the OP 100 D), or a variety of existing machines can

Fig 4. Plan views of focal troughs produced using the various imaging modalities. The outer (facial) and inner (lingual) 1.5 lp/mm resolution limits are mapped using thick dotted lines. The continuous line represents the region of maximum spatial resolution. A fine dotted line represents the midsagittal plane in each case.

be retrofitted. In both cases, it requires an added investment in the order of \$15,000 to \$20,000. Dosage requirements vary with the system and can be greater, the same, or less than that needed with traditional analog film-screen radiography. Storage phosphors provide an alternative approach that can be retrofitted to any existing panoramic x-ray generator. Scanners presently cost approximately \$20,000 so the cost is comparable to a CCD if only one unit is to be used. Storage phosphors provide a digital readout following laser scanning; however, scanning times with the DenOptix system were 2 minutes 38 seconds for panoramic radiographs processed at 150 dpi, and precisely twice that time when scanning at 300 dpi. The DenOptix phosphor plate drum scanner can only process one plate at a time. This compares to a film processor where different films can be fed each few seconds and the total processing time per film is typically 90 seconds to 5 minutes. A third way to achieve digital panoramic radiographs would be to process analog film and then digitize this using a scanner or digital camera. The authors are unaware of

any combined film processor and scanner on the market at this time.

CONCLUSIONS

It is concluded that the prototype OP 100 D provides an instant image with a wide focal trough making patient radiation dose positioning error unlikely, but requires a patient higher than that for film. While the DigiPan does significantly reduce the patient dose to radiation and also provides an instant image, the focal trough is narrower making patient positioning error more likely. The DenOptix storage phosphor system provides high resolution and a reasonable focal trough width, but the procedure takes longer than traditional film radiography and does not provide any dose saving. The relative roles of the receptor, computer-controlled motion of the assembly, and the secondary slit collimator while using each sensor type could not be ascertained. It is assumed that properties of the receptors per se did not account for the variations found in the focal trough width.