Clinical Trial of Panoramic Dental Radiography Using a CCD Receptor

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The objective of this study was to evaluate the perceived clinical efficacy of a charge-coupled device (CCD) detector for panoramic radiography by comparing the images produced to conventional film/screen radiographs using the same machine and patient population. For clinical evaluation, 18 criteria were selected. These included overall assessment of the area of coverage, clarity of dental structures, clarity of bony outlines, specific anatomic details such as the maxillary sinus floor, mandibular canal and mandibular condyle, and region-by-region assessment of the dentition. Observers acted independently using identical optimal viewing conditions. Film and digital radiographs were evaluated separately. A five interval Likert rating scale was used. Digital images were rated superior to the conventional film radiographs for 14 criteria. Film radiographs marginally outperformed digital images for three criteria. For one criterion (periodontal bone status) the two modalities showed no difference in terms of the mean ratings. It was concluded that digital images are clinically equivalent to conventional film/screen images for panoramic dental radiography.

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FROM THE CLINICIAN'S viewpoint, diagnostic radiographs should possess fidelity, clarity, and also be attractive.¹ Fidelity and image clarity can be expressed in terms of spatial resolution, gray-scale resolution, gray-scale linearity, the signal-to-noise ratio, and minimization of distortion.^{1,2} Image attractiveness concerns the perceived esthetics of the displayed image and involves the preferences and opinions of individuals. When a modality is introduced, there may be a learning curve delay in acceptability of the new esthetic.

This paper compares the perceived quality of panoramic dental images obtained using both digital (CCD) and analog (radiographic film) receptors. It evaluates the subjective issue of image attractiveness.

MATERIAL AND METHODS

X-Ray Generator

The Orthopantomograph OP 100 (Instrumentarium Imaging, Tuusula, Finland) is a software controlled high frequency dental panoramic x-ray machine operating at variable current ($2-10 \pm 1$ mA) and variable potential difference ($57-85 \pm 5$ kVcp) with an exposure time of 17.6 ± 0.05 s for standard panoramic

imaging. For film-based images the manufacturer recommends Lanex Regular screens combined with T-Mat G film (Eastman Kodak, Rochester, NY).

DigiPan Image Receptor

The DigiPan conversion interchanges with the standard film cassette for the Orthopantomograph OP 100. The CCD matrix is 1244×63 with pixel dimensions of $104 \mu\text{m} \times 104 \mu\text{m}$ and an active area measuring 129.4×6.6 mm. The uncompressed image matrix is 2550×1244 over an area of $265 \text{ mm} \times 129$ mm. A rare-earth scintillator converts x-radiation to light. The scintillator is separated from the CCD via a non-tapered fiber optic. The acquisition is 10 bit, but storage is of an autocompensated 8 bit TIFF image. The image file size is 3 Mbyte ($3,021,616$ byte) without compression.

The maximum DigiPan image length of 265 mm is not very different from that with film where the maximum length is 300 mm. The maximum image height of 129 mm for the DigiPan is compares to the range of 125 mm to 150 mm found with film.

Sample

The subjects comprised a presenting sample of individuals requiring panoramic radiography for diagnostic purposes. They were invited to participate in this clinical trial and informed consent was obtained in each case as approved by the Institutional Review Board.

Radiograph/Image Acquisition

Film images were performed using Kodak T-Mat G film combined with Lanex Regular screens (Eastman Kodak, Rochester, NY, USA).

Digital images were made using the DigiPan detector (Trophy Radiologie, Vincennes, France) for the Orthopantomograph 100 rotational panoramic machine (Instrumentarium, Tuusula, Finland). All diagnostic images were found by consensus to be of good overall diagnostic quality irrespective of whether film-screen or digital in acquisition.

Observers and Observations Criteria

The two evaluators were dentists with experience in general dental practice combined with advanced credentials in Oral and Maxillofacial Radiology. Each film radiograph and digital image was evaluated separately under subdued ambient lighting. The evaluators worked independently. Eighteen separate criteria

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were considered using a Likert scale: (1) unusable; (2) poor; (3) satisfactory; (4) good; and (5) excellent. The criteria were: adequacy of area of anatomical coverage, overall clarity of dental structures, overall clarity of bony outlines, and specific structures including the maxillary incisors, the mandibular incisors, the maxillary canines and premolars, the mandibular canines and premolars, the maxillary molars, the mandibular molars, the lower border of the mandible, the mandibular canals, the outlines of mandibular condyles, the floor of the maxillary sinus, the outline of the nasal cavity, the lower border of orbit, periodontal bone level, restorations in teeth, and endodontic fills.

The rankings for each criterion for all patients were averaged for both observers then combined separately for film and digital images. The average ranking for each film image/patient was subtracted from that for each digital image for each criterion. A positive score indicated the digital images to be of higher rank. A negative score indicated the film image to be of higher rank.

RESULTS

An overview of the results is given in Table 1.

Adequacy of Anatomical Coverage

Both modalities (film and digital) were found to be good to excellent and none of the ratings given were less than satisfactory.

Overall Clarity of Dental Structures

DigiPan images marginally outperformed conventional radiographs according to the observers; however, there was some inconsistency in averaged rankings for images from different patients.

Table 1. Mean Rating Scores for Specific Criteria

Criterion	DigiPan		Film	Not Pertinent*	Mean Difference
	Equal	Preferred	Preferred		
Anat coverage	5	7	0	0	+0.67
Dent structures	3	7	2	0	+0.67
Bony outlines	6	3	3	0	+0.17
Max incisors	4	3	5	0	-0.08
Mand incisors	4	4	4	0	+0.25
Max premolars	3	7	2	0	+0.58
Mand premolars	7	5	0	0	+0.50
Max molars	3	7	2	0	+0.42
Mand molars	3	6	3	0	+0.58
Mand canals	4	8	0	0	+1.00
Mand border	2	9	1	0	+1.80
Condyle	3	5	4	0	+0.08
Max sinus	7	3	2	0	+0.25
Nasal cavity	6	2	4	0	-0.33
Orbit border	3	4	5	0	-0.03
Perio status	2	6	4	0	0.00
Restorations	2	7	0	3	+1.00
Endo treatment	2	0	0	10	+1.50

*All subjects were dentate. Three patients had no restorations. Only two had endodontic fillings.

Overall Clarity of Bony Outlines

DigiPan images marginally outperformed conventional radiographs according to the observers. Bony outlines were perceived to be better displayed by both receptor modalities than were the dental structures.

Specific Dental Arch Segments

For the incisor region DigiPan images were marginally preferred for the mandible and film was rated very slightly better for the maxilla. In the canine/premolar and the molar regions, both for the maxilla and the mandible, DigiPan radiographs were preferred for viewing the teeth.

Specific Bony Structures

DigiPan images were preferred for delimitation of the bony outlines of the mandibular canals, the lower border of the mandible, the mandibular condyle and the lower border of the maxillary sinuses. Film radiographs were marginally preferred to DigiPan images for viewing the lower border of the orbit and the outline of the nasal cavity.

Periodontal Status and Dental Restorations

No preference was found between the two imaging modalities with respect to their ability to demonstrate the periodontal bone status. DigiPan images were preferred for evaluation of coronal and intracoronar dental restorations and endodontically filled teeth.

Interoperator Variation

Observer 1 consistently gave higher ratings; however, the differences were consistent across modalities and average ratings for each modality were generally in the same order sequence.

DISCUSSION

Essentially, clinical equivalence between the digital and film based receptors proved to be the case. While the DigiPan images were preferred over film radiographs for most of the criteria studied, the differences were slight. In view of the slightly smaller area actually available on the DigiPan receptor surface, the authors were surprised that the digital images were rated better than the film radiographs in terms of the anatomic coverage—and the better consistency in displaying

both the lower border of the mandible and the mandibular condyles.

It can be concluded that the DigiPan produces an excellent image of diagnostic equivalence to standard film/screen radiographs. The lack of need of retakes shows that the system is easy and safe to use. It also indicates that the approximately 70% reduction in radiation dose we have reported in an earlier communication is a real savings.³

REFERENCES

1. Kundel HL: Visual perception and image display terminal. *Radiol Clin N Amer* 24:69-78, 1986
2. Cox JR, Muka E, Blaine GJ, et al: Considerations in moving electronic radiography into general use. *IEEE Select Areas Commun* 10:1108-1120, 1992
3. Farman TT, Kelly MS, Farman AG: The OP 100 Digipan. Evaluation of the image layer, magnification factors, and dosimetry. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 83:281-287, 1997