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Quality comparison of direct digital panoramic radiography and computed radiography panoramic

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Original Article

Abstract

BACKGROUND AND AIM: Digital panoramic X-ray images can be captured using photostimulable phosphors or solid-state detectors (i.e. charge-coupled devices and Flat-Panels). The first category is defined as computed radiography (CR) or semi-direct radiography. The second technology that uses solid-state detectors is known as direct digital radiography (DDR). Both of these technologies have their own advantages and disadvantages. One of the most important fields in comparison of these systems is their resultant image quality. The purpose of this study was to compare the subjective image quality of DDR and CR digital panoramic system, and to assess the overall density and contrast of their images.

METHODS: 200 patients were randomly allocated to two digital systems: Promax [central control digital (CCD)] and XC [photostimulable phosphor plates (PSP)]. Image quality was evaluated in six regions on a 3-point scale by three oral and maxillofacial radiologists independently. In addition, observers assessed overall density and contrast of each image on a 3-point scale.

RESULTS: Using chi-square test, no statistically significant differences were found ($P > 0.05$) in subjective image quality of anatomic structures between the two radiographic systems. But DDR system outperformed CR system in overall density and contrast of the image. P values for both overall density and contrast of the images was less than 0.001.

CONCLUSION: The subjective image quality of CR and DDR panoramic systems in specified anatomic regions were found statistically comparable in this study. In overall density and contrast of the radiographs, DDR system proved better than CR system.

KEYWORDS: Dental Radiography, Digital Dental Radiography, Panoramic Radiography, Direct Digital Radiography, Computed Radiography

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Since the introduction of intra–oral digital systems in 1980s with the commercial name of RVG (Radio-Visio-Graphy), this technology has found its way in several dental X-ray images from simple intraoral to more complex extraoral and CBCT (Cone beam computed tomography) images. Digital technology is revolutionizing different branches of dentistry and at the forefront of this evolution is the field of oral and maxillofacial radiology. Radiology centers are increasingly adapting to digital systems.

The advantages of these systems are as the following: the elimination of darkroom processing stages, faster access to the provided images, easier image processing and maintenance, the ability to create multiple copies of a single image and being more eco-friendly.[1] Another advantage of this system is more clinical convenience.

In DR systems the captured image can be viewed instantly on the monitor. As a result, errors on the image can be detected and

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corrected instantly. Furthermore these systems give us the ability of image manipulation using the software. This manipulation is especially important in PSP plates. PSP receptors have a wide dynamic range. Thus by image manipulation, we can produce clinically acceptable images from a wide range of exposure conditions.[2,3]

Since the early days of the introduction of these systems, many studies were conducted to compare this emerging technology with conventional systems. Digital technology used in receptors was developed in separate branches. Mainstream technologies are:

Solid state: which is consisted of three sub categories i.e. CMOS (complementary-symmetry metal–oxide–semiconductor), CCD and flat panel PSP

These systems can also be divided into two groups: CR and DDR. In CR or computed radiography, image receptor is a plate which is placed in a cassette. After exposure this plate is transferred to a laser scanner and the data is transmitted from the scanner to the computer for processing stages. Obviously in this method we have an offline processing. That is why we call it a "semi-direct system". On the other hand we have DDR or direct digital radiography in which a sensor captures the image and sends it directly to a computer. On computer the operator can process the image.[4]

Methods

This study was performed on 200 panoramic radiographs of which 100 panoramic radiographs were obtained by the method of direct digital radiography and 100 radiographs obtained by the method of computed radiography. Inclusion criteria for selected cases were: patients were between 18 to 44 years old and no limitation was exerted about the gender.

118 of the patients were males and 92 of them were females. Edentulous patients, those with developmental problems or a history of systemic disease, trauma and neoplasm were excluded from this study because of possible deformation of oral and dental structures.200 cases in this study went under X-ray examination for usual dental cares and were divided into two equal groups randomly.

First group was exposed by Promax (Planmeca, Finland) which is a CCD based imaging system. This system is direct digital radiography. Exposure parameters in this system varied from 68 KVP to 72 KVP and 12 to 15 mA. Second group was exposed by XC (Planmeca, Finland) and was scanned by Agfa CR (Agfa, Belgium) equipment. Exposure parameters in this system varied from 68 KVP to 72 KVP and 12 to 12 mA. Imaging in both groups was performed by a single technician to keep the same exposure values and patient positioning as much as possible.

Images acquired from DDR system (Planmeca, Finland) were processed with Romexis software version 3.2 (Planmeca, Finland) and images acquired through CR systems were processed by NX software (Agfa, Belgium). Processing stages of each image included cropping the image and primary adjustment of contrast and brightness of the image within usual range limits processing stage was also performed by a single person to keep the same image quality factors except for imaging method. Processed images were stored in JPEG format. Resultant images were cropped again to hide the patient information and system name by Photoshop Cs5 Mac edition software. Then numbers were assigned to image files randomly. 200 images were evaluated by 3 oral and maxillofacial radiologists on a single workstation independently. The software used to view these images was windows image viewer and the monitor used for this purpose was LG-E1752 S with the aspect ratio set to 3.4. Radiographs were evaluated by 3 oral and maxillofacial radiologists. Evaluated structures included:

Periodontal bone level
Trabecular bone
Inferior wall of maxillary sinus
Inferior alveolar nerve canal
Lamina dura around the teeth
Root canal space of single root teeth

Number 1 structure was selected from alveolar bone structure and number 2, 3 and 4 structures were chosen from vital structures and number 5 and 6 structures were selected from dental structures in a panoramic image.

All of these structures in early images were evaluated on the basis of a 3 units scale.

1- Not evaluable
2- Uncertain evaluation
3- Completely obvious

Contrast is defined as the difference between light and dark densities in a radiograph. Density is described as the overall darkening of a radiograph. These two characteristics have a great impact on overall quality of a radiograph.[1]

The overall contrast and density of radiographs were also compared by the 3 radiologists in this study and were scored on a 3 unit scale as follows:

1- Excellent
2- Appropriate
3- Acceptable

Results collected from 3 radiologists were analyzed statistically by the SPSS software version 16 and using Chi-Square statistical analysis. Statistical significant level was considered 0.05.

Results

DDR and CR technologies revealed no significant difference in quality (P = 0.900) (Table 1).

DR technology was better than CR technology in density and contrast (P< 0.01) (Table 2).

Table 1. Results of evaluation of the observers in relation to each study variable

Structure	Group	Number in group			P
		Not evaluable	Uncertain evaluation	Completely obvious	
Crestal bone level	CR	0	2	98	1.000
	DR	0	3	97	-
Trabecular bone	CR	0	3	97	0.500
	DR	1	5	94	-
Maxillary sinus wall	CR	9	12	79	0.080
	DR	4	22	74	-
Inferior alveolar canal	CR	23	41	36	0.740
	DR	26	43	31	-
Lamina dura	CR	18	70	12	0.390
	DR	16	65	19	-
Root canal space	CR	3	43	54	0.900
	DR	2	43	55	-

CR: Computed radiography; DR: Digital radiography

Table 2. Results of evaluation of the observers in relation to the general characteristics of the images

Characteristic		DR (%)	CR (%)	P
Density	Acceptable	7	13	< 0.001
		78	43	-
		9	50	-
Contrast	Acceptable	6	25	< 0.001
		43	65	-
		51	10	-

CR: Computed radiography; DR: Digital radiography

Discussion

The results of this study were to some extent different from the results of the only similar study that we could find in this field. In the study conducted by Benediktsdottir et al.[5] the quality of systems were found to be significantly different.[5] The cause of this difference can be due to the evaluated structures. In Benediktsdottir et al. study only periapical sites of 6 areas were evaluated while in this study we evaluated a broader range of structures, like inferior wall of the sinus and inferior alveolar nerve canal. Secondly, the imaging system manufacturers were different and the mentioned study was conducted in 2003 with somehow older equipment. Due to high speed evolution of imaging systems, the reason of this difference between studies seems obvious.

In some similar studies dental structures were evaluated[5] and in some others anatomical structures[6] and pathologic changes[7] were evaluated. In this study, the objective was the evaluation of the quality of at least one usual anatomic structure in each of the following categories: 1-bone and peripheral structures 2- alveolar bone 3-dental structure.[1] The criteria was selected in this way:

1- Periodontal bone level, 2- trabecular bone, 3- inferior wall of maxillary sinus, 4- inferior alveolar canal, 5- lamina dura around the teeth, and 6- root canal space in single root teeth.

Number 1 structure was selected from alveolar bone structure and number 2,3 and 4 structures were selected from vital structures and number 5 and 6 structures were selected from dental structures in a panoramic image.[8] Structures such as mental foramen were not included in this study because of their high variations and their dependence on the angle of central beam.

Generally similar studies were conducted in two ways:

1- Different samples were evaluated in different imaging systems.[5,7]

2- The same cases were evaluated in various systems. They have captured images from the same person by different methods.[6,9]

The second method is more precise but, because of moral considerations i.e. second exposure of patients to X-radiation, we chose the first approach. We tried to improve the accuracy of reported results by increasing the sample size and selection of 6 anatomical landmarks. Variable structures such as mental foramen seem more appropriate for studies using the second method.[6]

The results would be more precise if we could compare two systems with the same panoramic machine (e.g. both were Promax). Using two different panoramic machines means different projection geometries which leads to different image qualities. Except for Benediktsdottir et al. study other studies compared conventional panoramic system with digital systems.[6,10-13] For intraoral systems unlike extraoral systems, many studies compared the quality.[14,15] And the results were not similar between these studies.

Conclusion

Two systems of CR and DR were equal in the clarity of the assessed structures. But general image characteristics i.e. density and contrast in DR systems proved to be somehow superior to CR systems.

Conflict of Interests

Authors have no conflict of interest.

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