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Skin entrance dose for digital and film radiography in Korean dental schools

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ABSTRACT

Purpose : This study was aimed to compare skin entrance dose of digital radiography with that of film radiography and to show the dose reduction achievement with digital systems at 11 dental schools in Korea.

Materials and Methods : Forty six intraoral radiographic systems in 11 dental schools were included in this study. Digital sensors were used in 33 systems and film was used in 13 systems. Researchers and the volunteer visited 11 dental schools in Korea. Researchers asked the radiologic technician (s) at each school to set the exposure parameters and aiming the x-ray tube for the periapical view of the mandibular molar of the volunteer. The skin entrance doses were measured at the same exposure parameters and distance by the technician for each system with a dosimeter (Multi-O-Meter : Unfors instruments, Billdal, Sweden).

Results : The median dose was 491.2 μGy for digital radiography and 1,205.0 μGy for film radiography. The skin entrance dose in digital radiography was significantly lower than that of film radiography ($p < 0.05$).

Conclusion : Fifty-nine percent skin entrance dose reduction with digital periapical radiography was achieved over the film radiography in Korean dental schools. ***(Korean J Oral Maxillofac Radiol 2005; 35 : 203-5)***

KEY WORDS : Digital Radiography; Film; Radiation Dose

Introduction

Since the first machine-wrapped dental film packet was introduced in 1919, x-ray sensitive film has remained virtually unchallenged as the image receptor for intraoral radiography. The introduction of double-sided emulsion in 1924 and progressive increases in film speed over the years have resulted in lower radiation doses while maintaining image quality at an acceptable level. Film remains still a cheap and reliable method of recording images in dental radiography.[1] The use of faster films (E-or F-speed) is preferred because they reduce the radiation dose.[2] E-speed film have twice the sensitivity of D-speed film. F-speed film requires about 75% the exposure of E-speed film and only about 40% that of D-speed.[3] The fast F-speed film available today can be used in routine intraoral radiographic examinations without sacrifice of diagnostic information.[4]

In 1987 the Trophy RadioVisioGraphy system, the first intraoral sensor and display processing unit with the x-ray image on a television monitor, became available as an alternative to conventional radiography.[5] Since then many other systems have been introduced. The application of computer technology to radiography has allowed image acquisition, manipulation, storage, retrieval, and transmission to remote sites in a digital format.[6] The digital image is a dynamic image; i.e. its contrast and density can be changed according to the diagnostic task which is not the case with film. The capacity for postacquisition manipulation provides the clinician with the potential to obtain more information from the image and can reduce the number of images that need to be retake because of overexposure or underexposure. The use of digital technology also results in a 50% to 95% reduction in patient exposure owing to the greater sensitivity of the digital receptor.[1,2,6]

Korean dental schools are making the transition from conventional film radiography to digital system. This study was aimed to compare the skin entrance dose of digital radiography with that of film radiography and to show the amount of dose reduction achievement with digital systems at dental schools in Korea.

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Materials and Methods

Forty six intraoral radiographic systems in 11 dental schools were included in this study. Digital sensors were used in 33 systems and films were used in 13 systems. Insight film (Eastman Kodak, Rochester, NY, USA) was the image recorder for 10 systems and E-speed film (Eastman Kodak, Rochester, NY, USA) for 3 systems. The digital radiographic system sensors were composed of 9 Sigma (GE/Instrumentarium Imaging, Tuusula, Finland), 8 Suni (Suni imaging Microsystems Inc, San Jose, CA, USA), 1 RVG ultimate (Trophy Radiologie, Vincennes, France), 10 Schick (Schick Technologies Inc, Long Island, NY, USA) and 5 RVG 6000 (Eastman Kodak, Rochester, NY, USA).

A 24-year-old man (height 172 cm, weight 70 kg) volunteered for this study. Researchers and the volunteer visited 11 dental school in KOREA. Researchers asked the radiologic technician (s) at each school to set the exposure parameters and aiming the x-ray tube for the periapical view of the mandibular molar of the volunteer.[7] A researcher measured the focal spot-to-skin distance with a ruler. The technician was asked to aiming the tube three times, and the focal spot-to-skin distance was measured each time.

A dosimeter, Multi-O-Meter (Unfors instruments, Billdal, Sweden) was used to measure the skin entrance dose (μGy). The skin entrance doses were measured at the same exposure parameters and distance by the technician for each system.

The skin entrance doses for digital and film radiography were analyzed with SPSS. Normality of the dose data was explored using the Shapiro-Wilk test. After the normality was rejected, the interquartile range (IQR) and median were calculated. The medians were compared using Mann Whitney U test.

Results

The skin entrance doses of the digital systems explored with Shapiro-Wilk test departed from normality.

The median doses were 491.2 μGy for digital radiography, with an IQR of 449.02 μGy and 1205.0 μGy for film radiography, with an IQR of 460.90 μGy. The median of the skin entrance dose of the digital radiography was significantly lower than that of the film radiography by Mann Whitney U test ($p < 0.05$). There are two outliers away from the boxplot of digital radiography, which indicates that those two doses are exceptionally high. The digital radiography showed 59% skin entrance dose reduction over the film radiography (Fig. 1).

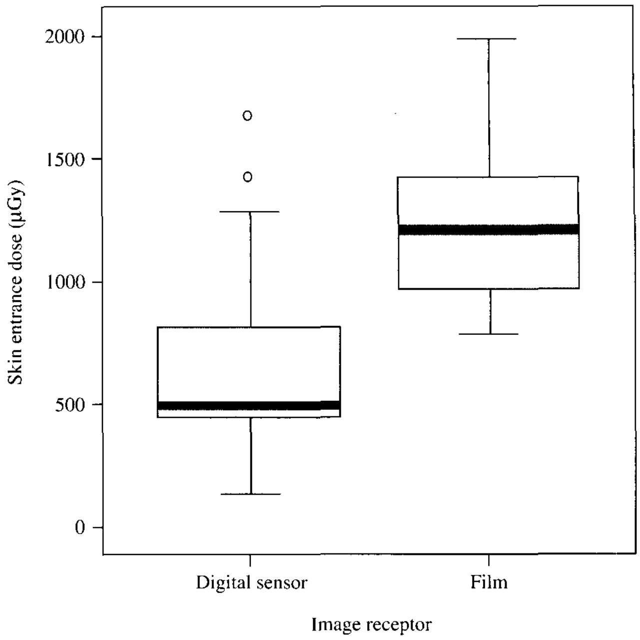

Fig. 1. Boxplots representing the distribution of skin entrance dose (μGy) for digital radiography and film radiography. There were 2 ouliers in digital radiography. The median was lower in digital radiography than film radiography with statistical significance ($p < 0.05$) by Mann Whitney U test.

Discussion

The guiding principle for use of diagnostic radiology in dentistry is to enhance the diagnostic benefits of dental radiographs and minimize the associated radiation risks to patients and staff. The overriding principle behind reducing radiation risk is to use exposures that are as low as reasonably achievable-that is, the ALARA principle. Since the way in which the examination is conducted greatly influences patient exposure to x-radiation, with the consistent image quality required for diagnostic task, it is good to select the image receptor of maximum sensitivity.[2]

Digital radiography has been proved to be a successful substitute for film radiography in the respect of image quality.[8] Most current x-ray detectors generally perform well in terms of spatial and contrast resolutions.[9] As for diagnostic quality, digital radiography is as accurate as film radiography for the detection of caries.[10-13] For detection of approximal dentinal lesions, sensitivities, specificities as well as the predictive values are fair with digital radiography.[10] Digital radiography has no difference from film radiography for the diagnostic ability of incipient caries.[14]

It is known that digital dental radiography requires less x-ray exposure than film for diagnostically acceptable radiographs.[1,2,5,8,15-21]

There were, however, abnormally high doses with two digital systems (RVG 6000 and Suni) (Fig. 1). This seemed to be caused by wide dynamic range of the digital systems.[9] Digital radiography with wide dynamic range can detect very small signals as well as very large signals without the signals being lost in the electronic noise.[18] The digital systems with wide exposure range produce good quality radiographs even at high exposure times, which may result in an unnecessarily high dose.[19,22] In addition, dentists have a tendency to select higher exposure times to get nicer or less noisy radiographs, for noise will increase at a lower dose and the diagnostic value of the radiograph will decrease. It could result in unnecessarily high radiation dosages being applied to the patient if care is not taken to avoid this eventuality.[9,19,22] In contrast, the digital systems with narrow exposure range can alert the dentist when a too long exposure time is used by a lack of image quality.[1,19] In addition, digital radiography has the possible risk of increasing the number of exposures and the dose required to obtain images of enough quality. The digital sensors with the active area smaller than a standard intraoral film require more exposures to cover the same area of interest.[17] Positioning digital sensor is significantly more difficult than positioning film, which may lead to more errors and consequently, more retakes.[17,23] Additionally, it is easier and less time consuming to produce a digital image than to process a film radiograph, which may let dentists take more radiographs.[20] Taking these into consideration, it is questionable whether the total radiation dose with digital radiography is so much lower than it is with film radiography. Therefore, careful attention should be paid to the radiation protection issues of digital radiography.

However, the detrimental effects of inadequate film processing on diagnostic quality and the difficulty of maintaining high-quality chemical processing are problems in dental radiography. Hazardous wastes in the form of processing chemicals and lead foil are eliminated with digital system. Image can be electronically transferred to other health care providers without any alteration of the original image quality. We proved that 11 dental schools in Korea using digital systems for intraoral radiography had achieved 59% dose reduction over film radiography. These advantages of digital system are driving the shift from film to digital system.

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