Reference dose levels for dental panoramic radiography in Anyang City

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ABSTRACT

Purpose : To measure dose-width product (DWP) values used for dental panoramic radiography in Anyang city, Korea.

Materials and Methods : Thirty-six panoramic dental radiographic sets (17 analogue panoramic sets and 19 digital panoramic sets) in 36 dental clinics in Anyang city were included in the study. Each patient's panoramic exposure parameters were simulated and the panoramic radiation doses were measured at the secondary collimator using a Mult-O-Meter (Unfors Instruments, Billdal, Sweden) at each dental clinic during 2006. The third quartile DWP was determined from 310 surface dose measurements on adult.

Results : The third quartile DWP for adult panoramic radiograph was 106.7 mGy mm. For analogue and digital panoramic radiograph, 3/4 DWP were 116.8 mGy mm and 72 mGy mm respectively. The overall third quartile DWP of panoramic radiography was 106.7 mGy mm.

Conclusion : The measured 3/4 DWPs were higher than the 3/4 DWP of 65 mGy mm recommended by NRPB. Dentists who are operating above the reference dose should lower their panoramic exposure doses below the recommended reference value by changing the exposure parameters and/or their panoramic equipments. (***Korean J Oral Maxillofac Radiol 2009; 39 : 199-203***)

KEY WORDS : Radiation; Gray; Panoramic Radiography

Introduction

Panoramic imaging is a technique for producing single tomographic images of facial structures, which include both maxillary and mandibular dental arches and their supporting structures.[1] Panoramic radiography delivers relatively small radiation doses, i.e. effective dose to the patient for single panoramic image is approximately equal to that from four intraoral images, both using state-of-the-art technique.[2]

Contemporary intensifying screens used in extraoral radiography utilize the rare-earth elements gadolinium and lanthanum. As compared with older calcium tungstate screens, rare-earth screens reduce patient exposure by as much as 55% during panoramic radiography. A further reduction in patient exposure during extraoral radiography may be achieved using T-grain film, which was introduced by Eastman Kodak Company.

For digital panoramic radiography using a charge-coupled device receptor, the maximum entrance dose reduction was 70% as compared with a conventional film/rare-earth screen combination.[3]

Diagnostic investigations utilizing ionizing radiation offer potential benefits to the health care of patients and are an accepted part of medical practice. However, it is recognized that exposure to such low doses of radiation in diagnostic radiology is associated with an increased risk in the long term of malignant disease in those irradiated, and there is also real, though low risk, of serious hereditary disease in their descendants.[4]

Recognition of the harmful effects of radiation and the risks involved with its use led the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) to establish guidelines to limit radiation exposure to both occupationally exposed individuals and the public. Since dose limits were first

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established in the 1930s, they have been revised downwards several times.[1] But the dose limits by NCRP and ICRP are not applied to either natural radiation or radiation exposure that patients receive in the course of dental and medical treatment.[5]

Present legislation requires that all dentists taking radiographs ensure that delivered doses are as low as is reasonably practical for a given diagnostic purpose.[6] And NCRP also recommended that panoramic X-ray machine shall be capable of operating at exposures appropriate for high-speed (400 or greater) rare-earth screen-film systems or digital image receptors of equivalent or greater speed.[7]

Several patient dose surveys have been performed in panoramic radiology over the years.[8-11] The results of these surveys indicated that there were a wide range in radiation exposure for nominally the same examination. One of the survey showed a factor about 200 between the highest dose (328 mGy mm) and the lowest dose (1.7 mGy mm).[8] While variations in patient size and composition can explain some of the observed variation, there are other causes. It is therefore obvious that there is some scope for dose reduction.[12]

Based on the national survey in UK, the first reference dose of 65 mGy mm has been established for a standard adult panoramic radiograph. This dose was based on the third quartile values for the distributions of doses found in the survey, ie 75% of hospitals use doses below the reference value for a given purpose.

The third quartile dose-width product (DWP) for standard adult panoramic radiography as determined by similar surveys reported in the UK in 1999, 2000, and 2006 and in Italy in 2003 were 67, 76, 67 mGy mm and 84 mGy mm respectively.[8-11]

There have been no known surveys for establishing reference dose level for an adult panoramic radiography in Korea. Authors surveyed adult panoramic radiographic exposures in Anyang City, Korea as a preliminary investigation of nationwide survey for establishment of Korean reference dose level of the panoramic radiography.

Materials and Methods

The study data were collected from university facilities, large hospitals, and private dental clinics over the period March 2006 to March 2007. Seventeen analogue panoramic units and 19 digital panoramic units were included. One of the digital units was equipped with storage phosphor plates (indirect digital technique), whereas the others used a direct digital CCD (charge-coupled device) system. The dose measuring techniques

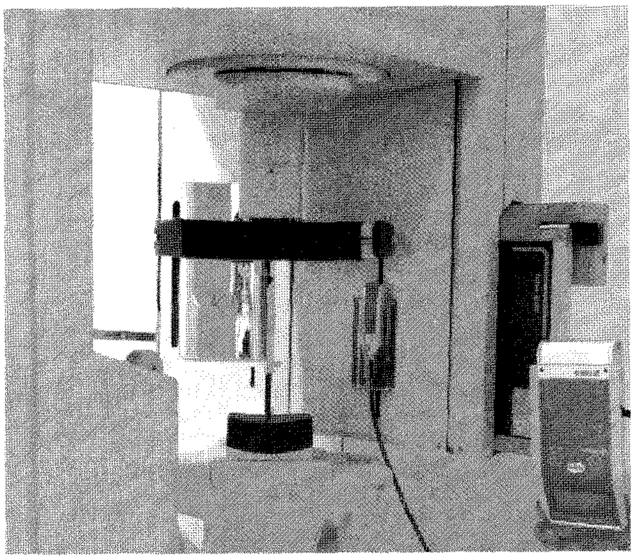

Fig. 1. The solid state detector was connected through a wire to the main body of dosimeter. The detector was inserted into the plastic receptor with magnet attached to the front side of the secondary collimator parallel to and middle of the slit.

used in this study were based on the NRPB assessment panoramic X-ray sets proposed by Napier in 1999; measuring the absorbed dose (to air) at the front side of the secondary collimator, integrated over a standard adult exposure cycle.[8] This is referred to as the dose with product (DWP) with units of mGy mm.

After each adult dental patient's panoramic exposure, a custom made plastic receptor with magnet for a rectangular shaped solid state detector was attached to the front side of the secondary collimator parallel to and middle of the slit or to the center of the digital sensor. The detector was inserted into the plastic receptor (Fig. 1). The solid state detector was connected through a wire to the main body of dosimeter (Unfors 577L Mult-O-Meter: Unfors Instruments AB, Billdal, Sweden). The solid state dose detector had an active width of 1.5 mm and was calibrated by Swedish Radiation Protection Institute and The John Perry Radiation Metrology Laboratory.

Care had been taken to ensure that the length of cable attached to the detector was sufficient to allow the rotational movement required during a scan.

After positioning the detector, the exposure parameter of each patient's exposure was simulated and radiation was exposed and the exposure dose was recorded.

To measuring the real horizontal panoramic radiation beam width, a periapical film was attached at the second collimator for each panoramic unit and exposed for a scan cycle. The beam

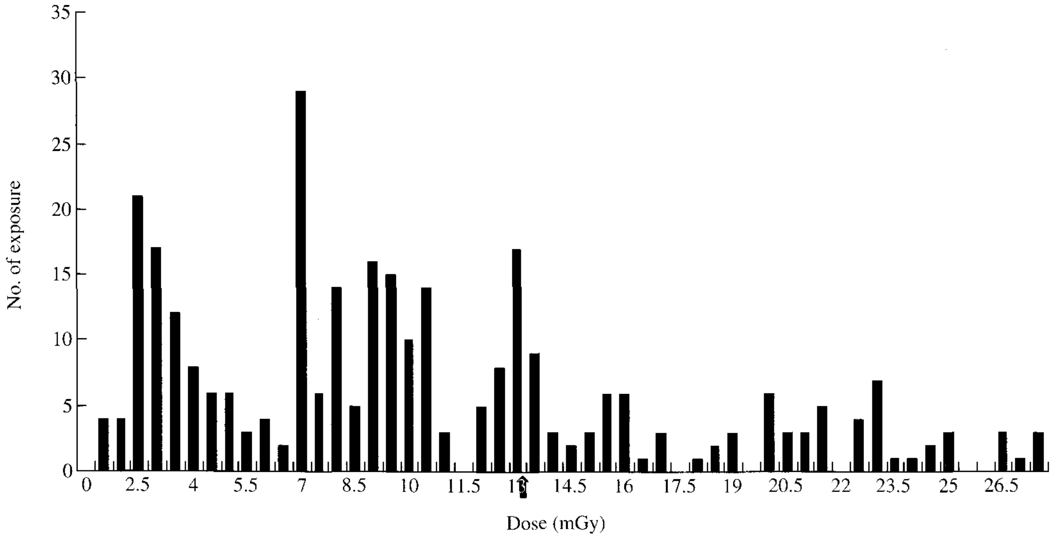

Fig. 2. Distribution of entrance surface exposure of panoramic radiography. The black arrow indicates the third quartile dose of 13.3 mGy.

width was obtained by measuring the dark band width of the film after developing. The dose per exposure cycle was multiplied by the horizontal beam width of the corresponding panoramic unit for calculating DWP.[8,9]

A total of 310 panoramic entrance surface dose measurements were performed on adult patient. The exposure parameters of kVp, mA, exposure time, and beam width were recorded. The statistical analysis was performed using mean, lowest, highest, and third quartile for the surface exposure doses and the DWP values.

Results

Tube potential settings ranged between 55 kV and 85 kV, exposure times times between 8 s and 21 s, fuse current values between 3.2 mA and 16 mA, and beam widths between 5 mm and 15 mm.

The distribution of entrance surface exposure is shown in Table 1 and Fig. 2. There is a factor of around 23 between the highest dose (27.2 mGy) and the lowest dose (1.2 mGy) for analogue panoramic unit. The mean patient entrance surface dose is 13.9 mGy and the third quartile dose is 18.7 mGy for the analogue unit.

There is a factor of around 25 between the highest dose (24.5 mGy) and the lowest dose (1.0 mGy) for digital panoramic unit. The mean patient entrance surface dose is 7.3 mGy and the third quartile dose is 9.5 mGy for the analogue unit. The third quartile patient entrance dose of the digital unit is lower than that of the analogue unit by a factor of 2. The overall mean patient entrance surface dose is 10.1 mGy and the third quartile dose is 13.3 mGy.

The distribution of dose-width product of panoramic units is shown in Table 2 and Fig. 3. There is a factor of around 24 between the highest dose (180.2 mGy mm) and the lowest dose (7.5 mGy mm) for analogue panoramic unit. The mean patient entrance surface dose is 93.7 mGy mm and the third quartile dose is 116.8 mGy mm for the analogue unit. There is a factor of around 32 between the highest dose (196.2 mGy mm) and the lowest dose (6.1 mGy mm) for digital panoramic unit. The mean patient entrance surface dose is 55.3 mGy mm and the third quartile dose is 72.0 mGy mm for the digital unit. The third quartile DWP of the digital unit for lower than that of the analogue unit by a factor of 1.6. The overall mean DWP was 72.1 mGy mm and the overall third quartile DWP was 106.7 mGy mm.

Table 1. Distribution of entrance surface exposure of 36 panoramic X-ray units (mGy)

Panoramic units	Mean dose	Lowest dose	Highest dose	3rd percentile dose
Analogue units	13.9	1.2	27.2	18.7
Digital units	7.3	1.0	24.5	9.5
Overall	10.1	1.0	27.2	13.3

Table 2. Distribution of dose-width product of panoramic X-ray unit (mGy mm)

Panoramic units	Mean	Lowest	Highest	3rd percentile
Analogue units	93.7	7.5	180.2	116.8
Digital units	55.3	6.1	196.2	72.0
Overall	72.1	6.1	196.2	106.7

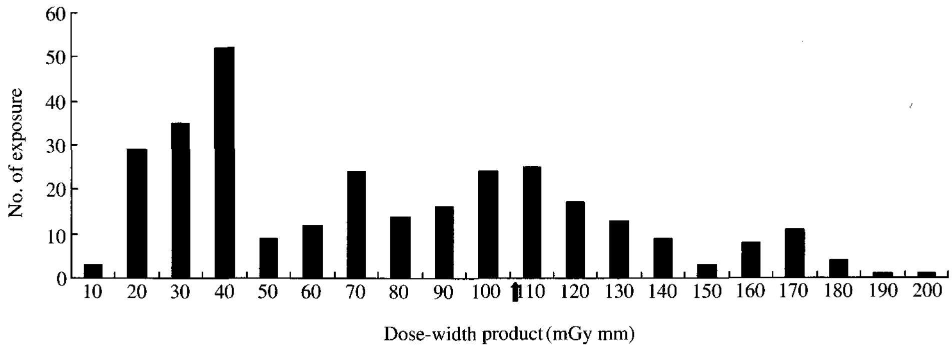

Fig. 3. Distribution of dose-width product (DWP) of panoramic radiography derived from the dose per exposure cycle multiplied by the horizontal beam width. The black arrow indicates the third quartile DWP of 106.7 mGy mm.

Discussion

The previous third quartile DWPs for standard adult film panoramic radiography were ranged from 67 mGy mm to 84 mGy mm.[8-11] But the third quartile DWP for film panoramic radiography in this study was 116.8 mGy mm. It is an apparent over exposure in the surveyed dental clinics. It is said the major cause of unnecessary exposure of the patient to radiation is the deliberate over exposure of films because over exposure is compensated by under development of the film resulting from reduced developing time, making timesaving to dental health care personnel. And the automatic film process could actually increase patient exposure if not correctly maintained.[1] The cause of this high value of DWP, however, should be investigated to enhancing dental patient protection from harmful ionizing radiation.

A more meaningful panoramic dosimetric measurement may be dose-area product (DAP), which takes into account the exposed area, is calculated from the product of DWP and the beam length. But most of the panoramic machines are now using almost the same sized film.

Doses associated with charge-coupled devices (CCD) and computed radiography systems (photostimulable phosphor luminescence technology) have been reported to be up to approximately 50% and 80% lower, respectively, than those associated with conventional technique.[1,3,13]

The value of third quartile DWPs in this study also showed 62% reduction in digital panoramic exposure (72.0 mGy mm) comparing to the film panoramic exposure (116.8 mGy mm). But there is a tendency to increase doses for higher image quality because higher doses may decrease the image noise for digital receptors in a certain range of dose.[14] Furthermore the ease of image acquisition with digital system may also lead to more exposure than clinically necessary.[15] Therefore, it is essential to ensure that all retakes are properly justified and recorded.[4,15]

Reference doses are base on the third quartile values for the distributions of doses found in surveys, ie, 75% of hospitals use doses below the reference value for a given purpose. The adoption of the third quartile value as a reference dose is of course a purely pragmatic approach that was introduced to identify the 25% of hospitals that were urgently in need of better quality control. It should be stressed that these reference doses are not statutory dose limits, rather they should be viewed as practical aids designed to promote better control.[8]

In the present study, measurements were done in μGy, but simplify these values with mGy will be sensible, because the dose levels quoted by other surveys and by the IAEA are expressed in mGy.[5,8-11]

Exposure parameters varied widely in this study, because dentists choose parameters based on personal knowledge and experience, and thus, DWP values differ for even the same panoramic units.[16]

In the present study, the beam width of digital and analogue units ranged from 5 mm to 10.5 mm and from 5 mm to 15 mm respectively. The beam width at the receiving slit or secondary collimator should be restricted to no greater that that required to expose the area of diagnostic interest and certainly no greater than the film or detector in use. Thus, it should be stressed that a beam width of no greater than 5 mm is required to reduce patient exposure.[4] Thus the beam width of the panoramic machine should also be considered for reducing patient radiation exposure.

Third quartile DWP value in this study was quite different from those reported by other countries, and is higher than that recommended by the NRPB. This difference may have been resulted from the differences in sample size or distribution or poor optimization.

It should be remembered that reference doses are not limit, rather they are guidelines intended to indicate current clinical practice. Equally, the attainment of doses at or below reference values cannot be constructed to mean the achievement of optimum performance. Clearly, because many dentists are already achieving doses significantly below the reference dose, further dose reductions are still practicable. Nevertheless, it is hoped that the majority of dentists operating above the reference dose will achieve reductions to below the reference value by making minor alterations to the technique or the equipment used.[8] And further study in the other region of Korea should be conducted to establish appropriate reference dose levels.

Conclusion

The overall third quartile DWP of 106.7 mGy mm, 116.8 mGy mm for analogue units, and 72.0 mGy mm for digital unit determined in this study could be used as a temporary guide to accepted clinical practice by dentists in Korea. However, this value of analogue unit is higher than the NRPB recommendation value of 65 mGy mm. Dentists using doses above this reference level, should undertake a thorough review of their radiographic practice and make every effort to reduce radiation exposure or upgrade their X-ray machines to a high-frequency modern unit. A further nationwide DWP survey is needed to establishing a Korean dental reference dose.

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