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Ebba Helmrot and Anne Thilander Klang, METHODS FOR MONITORING PATIENT DOSE IN DENTAL RADIOLOGY, 2010, Radiation Protection Dosimetry, (139), 1-3, 303-305.

is available online at: <http://dx.doi.org/10.1093/rpd/ncq095>

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Postprint available at: Linköping University Electronic Press

<http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-56758>

METHODS FOR MONITORING PATIENT DOSE IN DENTAL RADIOLOGY

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Short title: MONITORING PATIENT DOSE IN DENTAL RADIOLOGY

Abstract

Different types of X-ray equipment are used in dental radiology, such as intra-oral, panoramic, cephalometric, cone-beam computed tomography (CBCT) and multi-slice computed tomography (MSCT) units. Digital receptors have replaced film and screen-film systems and other technical developments have been made.

The radiation doses arising from different types of examination are sparsely documented and often expressed in different radiation quantities. In order to allow the comparison of radiation doses using conventional techniques, i.e. intra-oral, panoramic and cephalometric units, with those obtained using, CBCT or MSCT techniques, the same quantities and units of dose must be used. Dose determination should be straightforward and reproducible, and data should be stored for each image and clinical examination.

It is shown here that air kerma-area product (P_{KA}) values can be used to monitor the radiation doses used in all types of dental examinations including CBCT and MSCT. However, for the CBCT and MSCT techniques, the methods for the estimation of dose must be more thoroughly investigated. The values recorded can be used to determine diagnostic standard doses and to set diagnostic reference levels for each type of clinical examination and equipment used. It should also be possible to use these values for the estimation and documentation of organ or effective doses.

INTRODUCTION

Intra-oral, panoramic, cephalometric, cone-beam computed tomography (CBCT) and multi-slice computed tomography (MSCT) units are used for different types of X-ray examinations in dental radiology. The size of the exposed area and distribution of the radiation dose may vary a lot in CBCT. Both CBCT and MSCT are developing rapidly and will become more common in the near future. Film and screen-film systems have been replaced by digital receptors, and other technical developments have been made, offering the possibility of three-dimensional reconstructions.

Radiation doses are rarely documented in dental radiology and when they are, different quantities are used. This makes it difficult to compare the risks associated with different kinds of examination⁽¹⁾. It is important to be able to assess radiation doses in order to optimize examination techniques and to allow comparisons with respect to radiation risk and image quality. It is thus desirable that radiation doses be recorded in a simple and reproducible way for every dental image to allow for easy comparison between examinations using conventional techniques (intra-oral, panoramic and cephalometric) and computerised tomography examinations, CBCT or MSCT.

MATERIALS AND METHODS

The report from International Atomic Energy Agency (IAEA) “Dosimetry in Diagnostic Radiology: An International Code of Practise”⁽²⁾ and the report from the International Commission on Radiation Units and Measurement ICRU 74⁽³⁾ has been used for definitions of dose quantities. The quantity used in this study to describe patient doses resulting from different kinds of dental radiation examinations is the product of the air kerma and the area of the radiation field (P_{KA}), as suggested and used by Helmrot and Alm Carlsson⁽⁴⁾, Lofthag-Hansen et al.⁽⁵⁾ and Looe et al.^(6,7). P_{KA} values can be measured by a suitably calibrated P_{KA} meter (KAP meter)⁽⁴⁾.

The P_{KA} value for a typical dental MSCT examination of the upper or lower jaw is derived by measuring P_{KL} (the air kerma–length product) in the z-direction and multiplying it by the average width of the patient’s jaw in the x-y plane given by Lofthag-Hansen et al.⁽⁵⁾. The P_{KA} value is corrected for attenuation effects caused by the bow-tie filter, a filter used to balance the radiation dose to the detector of the MSCT scanner used (LightSpeed Ultra, GE Healthcare, Milwaukee, USA).

Patient doses, in terms of P_{KA} values, have been recorded for over 200 intra-oral units, 32 panoramic units, 3 cephalometric units, 5 CBCT units and one MSCT unit at different clinics in different parts of Sweden⁽⁸⁾. The image detectors used were intra-oral film (Kodak Insight, Kodak, USA), image plates (Digora, Soredex, Finland, and Vistascan, Dürr Group, Germany) and intra-oral direct digital sensors (Schick Technologies Inc., USA)⁽⁸⁾. The following instruments were used for measurements of radiation dose: the electrometers (Barracuda, Piranha, Doseguard 100) were used together with transmission ionisation chambers (VacuDap) and pencil ion chamber (WDCT) (all from RTI Electronics AB, Mölndal, Sweden). All instruments were calibrated in a reference laboratory (RTI Electronics AB, Mölndal, Sweden) using reference instruments with readings traceable to a primary standards laboratory. P_{KA} values obtained by the transmission ionisation chambers were corrected for radiation quality used. Correction for chamber attenuation was also performed according to the calibration protocol for the used chamber. For detailed information see Helmrot and Thilander-Klang⁽⁸⁾.

RESULTS

The results in Table 1 show the mean values of the P_{KA} values for different types of examination. It also indicates that P_{KA} values can be used to monitoring radiation dose in dental radiology, including MSCT examination. The method used to determine P_{KA} values for MSCT must be further evaluated for use in clinical practice. Table 2 gives the P_{KA} mean values for different image detectors used in intra-oral imaging, in the same kind of

examination. The results show that the types of detector and beam size have a considerable influence on the value.

DISCUSSION

P_{KA} values can be used to determine the diagnostic standard dose⁽⁹⁾ for clinical dental examinations with various kinds of equipment, and to establish diagnostic reference levels⁽⁹⁾. A P_{KA} meter could be built into the equipment or the value could be automatically calculated based on the exposure parameters. To be able to determine diagnostic standard doses correctly, P_{KA} values should be given together with other exposure parameters such as the tube voltage (kV), tube load (mA), exposure time (s) and beam filtration. It is important that the P_{KA} meter is accurately calibrated and that calibration is repeatedly controlled.

P_{KA} values, together with conversion coefficients for conversion from P_{KA} values to effective dose (not yet available for all kinds of examinations and X-ray units), can be used to calculate the effective dose to the patient^(4, 6, 10). The conversion coefficients depend on the body volume irradiated and the beam quality (tube voltage and beam filtration) used. If the conversion coefficients are known the effective dose could then be used to optimize the examination with respect to image quality and diagnostic task in dental radiology.

CONCLUSIONS

The radiation dose to the patient arising from dental examinations can be monitored by the air kerma–area product, P_{KA} , for all kinds of examination used in dental radiology and can be of great help in establishing exposure and/or examination protocols.

ACKNOWLEDGEMENT

Professor Gudrun Alm Carlsson is acknowledged for interesting discussions during this work.

FUNDING

This work was supported by the Swedish Radiation Safety Authority (Project SSI P 1604.07).

REFERENCES

1. International Commission on Radiation Protection. *Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103 (Elsevier Ltd) (2007).
2. International Atomic Energy Agency, IAEA. *Dosimetry in diagnostic radiology: an international code of practice*. Technical reports series, ISSN 0074–1914; no. 457, STI/PUB/1294 (Printed by the IAEA, Austria) (2007).
3. International Commission on Radiation Units and Measurement. *Patient Dosimetry for X-Rays used in Medical Imaging*. ICRU Report 74. J. ICRU **5**(2) (2005).
4. Helmrot E, and Alm Carlsson G. *Measurement of radiation dose in dental radiology*. Radiat. Prot. Dosim. **114**(1-3), 168-171 (2005).
5. Lofthag-Hansen S, Thilander-Klang A, Ekestubbe A, Helmrot E, Gröndahl K. *Methods for calculating effective dose on a cone-beam CT device: 3D Accuitomo and 3D Accuitomo FPD*. Dentomaxillofac. Radiol. **37**, 72-79 (2008).
6. Looe H K, Eenboom F, Chofo N, Pfaffenberger A, Sering M, Ruhmann A, Poplawski A, Willborn K and Poppe B. *Dose–Area Product Measurement and Determination of Conversion Coefficients for the Estimation of Effective Dose in Dental Lateral Cephalometric Radiology*. Radiat. Protect. Dosim. **124**, 181–186 (2007).
7. Looe H K, Eenboom F, Chofo N, Pfaffenberger A, Steinhoff M, Ruhmann A, Poplawski A, Willborn K and Poppe B. *Conversion Coefficients for the Estimation of Effective Dose in Intra-oral and Panoramic Dental Radiology from Dose–Area Product Values*. Radiat. Protect. Dosim. **131**, 365–373 (2008).

8. Helmrot E, and Thilander-Klang A. *Stråldoser inom odontologisk radiologi – metodutveckling och kartläggning*. Project SSI P 1604. 072009 (in Swedish) Manuskript (2009).
9. European Commission. *European guidelines on radiation protection in dental radiology*. Radiation Protection **136** (2004) ISBN 92-894-5958-1.
10. Thilander-Klang A, and Helmrot E. *Methods of determining the effective dose in dental radiology*. Radiat. Prot. Dosim. **139**, 306-309 (2010).

TABLES

Table 1. Mean values of P_{KA} values determined for different types of examination techniques in dental radiology. Digital receptors were used.

Type of examination	P_{KA} (mGy cm ²)
One intra-oral image	8-10
Panoramic, adult	80
Cephalometric profile image	50
Cephalometric PA (posterior-anterior) image	100
CBCT (40 mm x 40 mm, Accuitomo)	350
CBCT (60 mm x 60 mm, Accuitomo)	730
MSCT Implant upper/lower jaw	1250/2050

Table 2. P_{KA} mean values obtained using different types of image receptors for the intra-oral projection BW (bitewing) premolar or molar. The range of mean values includes different types of detectors and, for film, variations in the development conditions.

Type of detector	P_{KA} (mGy cm ²)
Film (Kodak Insight)	15-20
Image plate (Digora, Vistascan)	22-29
Direct digital (Schick)	8-10