Theodorakou C, Horner K & Walker, A (2009) "Survey of paediatric organ and effective doses in dental cone beam computed tomography", presented at IPEM, 14 – 16 December 2009, Liverpool, UK.

Survey of paediatric organ and effective doses in dental cone beam computed tomography

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Introduction

Cone beam computed tomography (CBCT) is an x-ray emerging technology with wide applications in dentomaxillofacial radiology. Dental CBCT has been associated with higher radiation risk to the patients than conventional x-ray imaging and a lower risk compared to multi-slice CT. Several studies have focused on assessing the radiation risk to patients using adult anthropomorphic phantoms but none has investigated the paediatric organ and effective doses. The aim of this study is to estimate average organ absorbed and effective doses to two paediatric anthropomorphic phantoms for a range of CBCT units and imaging protocols.

Methods and materials

Two ATOM tissue-equivalent anthropomorphic phantoms and thermoluminescent dosimeters (LiF:Mg,Cu,P) were used in the measurement of absorbed doses. An adult ATOM female phantom was used to simulate a teenager as there are no commercially available teenager tissue equivalent anthropomorphic phantoms. A 10 year old ATOM phantom was used to simulate a child. Absorbed doses were measured in the brain, salivary glands, thyroid gland, red bone marrow, bone surface, skin and lungs for four CBCTs units. Correction factors were applied to the skin, red bone marrow and bone surface doses for each phantom slice to account for the fraction of the total mass of the specified organ in the phantom. The effective doses were calculated using the ICRP 103 tissue equivalent factors.

Results and discussion

The thyroid, salivary glands and brain received the highest absorbed doses for both phantoms. The dose to the red bone marrow was low but its contribution to the effective dose was significant due to its high radiosensitivity. For most of the imaging protocols and CBCT units, the salivary glands contribute the most to the effective dose for the teenager phantom while for the 10 year old phantom there is an almost equal contribution from the salivary glands and thyroid gland. The effective doses ranged from 5 μSv to 99 μSv for the child phantom and from 4 μSv to 65 μSv for the teenager phantom. The maxilla imaging protocol of the Planmeca Promax 3D gave the lowest effective dose for both phantoms. The effective doses for the 10 year old phantom are higher than these of the teenager phantom for most of the CBCT units and imaging protocols. This is mainly due to the positioning of the thyroid, salivary glands and brain with respect to the primary beam. This study has found that the % radiation-induced fatal cancer risk for a 10 year old child undergoing a dental CBCT exam is 0.0005% and for a teenager is 0.0003%. The average effective dose found in this study was 41 μSv which is four times higher than the average panoramic to an adult published by the Health Protection Agency (HPA).

Conclusions

This study reported on organ and effective doses to paediatric phantoms for a range of dental CBCT units and imaging protocols. In addition, this study confirmed that CBCT radiation doses are one-twentieth of published MSCT radiation doses but four times higher than the average panoramic dose published by the Health Protection Agency (UK).

The research leading to these results has received funding from the European Atomic Energy Community's Seventh Framework programme FP7/ 2007-2011 under grant agreement no. 212246 (SEDENTEXCT: Safety and Efficacy of a New and Emerging Dental X-ray Modality).