Computational modeling of thyroid shields and lead eyewear and the impact on the absorbed doses of eye lens and thyroid gland in CBCT exams

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The cone beam computed tomography (CBCT) is a technology introduced in dental diagnostic radiology in the late twentieth century. Since then, the use of CBCT has increased significantly. Currently, there are more than 50 different equipment models [1], with several protocols and parameters for image exposure. Among the models, a large number of equipment with predefined fields of view (FOV) by the manufacturer, are commercialized and used [2]. The objective of this study was to evaluate the absorbed dose in the thyroid and in the eye lens when the patient uses individual protection. For this purpose, Monte Carlo (MC) simulation was performed for five different FOV sizes, available in the i-Cat classic CBCT equipment. The MCNPX radiation transport code and two virtual anthropomorphic phantoms FASH3 and MASH3 [3] were used to represent adult patients of both genders. The analysis was performed comparing the absorbed dose in the eye lens and thyroid, with and without thyroid shield and lead eyewear. Three different models of the lead eyewear and thyroid shield were evaluated. The results showed that all three-lead eyewear's were efficient in the protection of the eye lens. The absorbed dose in the eye lens varied between 1.36E-05 μGy and 9.88E-04 μGy. The difference in the absorbed dose in relation to the use of the lead eyewear presented a reduction of 15% for the 8 cm × 6 cm FOV (diameter × height) and 72% for the 14 cm × 22 cm FOV. In relation to the thyroid, only the shield that involved the whole neck contributed to the reduction of the absorbed dose by up to 70% (14 cm × 22 cm FOV). For the thyroid shields there was a maximum increase of 30% (14 cm × 22 cm FOV), consequently increasing the effective dose for the protocol. The results showed that the lead eyewear contributed to the protection of the eye lens. On the other hand, the efficiency of the thyroid shield depends on the utilized model.

Keywords: CBCT, Monte Carlo simulation, individual protection equipment.

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[1] R. Pauwels, G. Zhang, C. Theodorakou, A. Walker, H. Bosmans, R. Jacobs, R. Bogaerts, K. Horner, SEDENTEXCT Project Consortium, The British Journal of Radiology 87, 2014, 20130654.

[2] R. Pauwels, W. C. Scarfe, Radiation Dose, Risks, and Protection in CBCT, in: W. C. Scarfe, C. Angelopoulos (Eds.), Springer, Cham, New York, 2018, 227–46.

[3] V. F. Cassola, R. Kramer, C. Brayner, H. J. Khoury, Posture-specific phantoms representing female and male adults in Monte Carlo-based simulations for radiological protection, Physics in Medicine and Biology 55:15, 2010, 4399-430.