Evaluation of referential dosages obtained by Cone-Beam Computed Tomography examinations acquired with different voxel sizes

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Abstract

Objectives: The aim of this study was to evaluate the dose–area product (DAP) and the entrance skin dose (ESD), using protocols with different voxel sizes, obtained with i-CAT Cone-Beam Computed Tomography (CBCT), to determine the best parameters based on radioprotection principles. **Methods:** A pencil-type ionization chamber was used to measure the ESD and a PTW device was used to measure the DAP. Four protocols were tested: (1) 40s, 0.2 mm voxel and 46.72 mAs; (2) 40s, 0.25 mm voxel and 46.72 mAs; (3) 20s, 0.3 mm voxel and 23.87 mAs; (4) 20s, 0.4 mm voxel and 23.87 mAs. The kilovoltage remained constant (120 kVp). **Results:** A significant statistical difference ($p<0.001$) was found among the four protocols for both methods of radiation dosage evaluation (DAP and ESD). For DAP evaluation, protocols 2 and 3 presented a statistically significant difference, and it was not possible to detect which of the protocols for ESD evaluation promoted this result. **Conclusions:** DAP and ESD are evaluation methods for radiation dose for Cone-Beam Computed Tomography, and more studies are necessary to explain such result. The voxel size alone does not affect the radiation dose in CBCT (i-CAT) examinations. The radiation dose for CBCT (i-CAT) examinations is directly related to the exposure time and milliamperes.

Keywords: Cone-Beam Computed Tomography. Radiation. Voxel.

Editor's summary

The voxel size, the smallest unit of a Cone-Beam Computed Tomography (CBCT) image, is related to the definition of tomographic image. The question raised by the authors of this study is whether voxel size can affect radiation dose during CT scanning. Measurement of dose-area product (DAP) and entrance skin dose (ESD) when

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TABLE 1 - Protocols for image acquisition for the i-CAT device.

Protocol	Scanning time (s)	Voxel size (mm)	Peak voltage (kVp)	mAs
1	40	0.2	120	46.72
2	40	0.25	120	46.72
3	20	0.3	120	23.87
4	20	0.4	120	23.87

TABLE 2 - Mean values of radiation doses (ESD and DAP) for the four protocols.

Protocol	Entrance Skin Dose - ESD (mGy)	Dose Area Product-DAP (mGy m²)
1	3.77	44.92
2	3.78	45.30
3	2.00	24.43
4	2.00	24.98
	(p = 0.00083)	(p = 0.000145)

obtaining CBCT images with an i-CAT (Imaging Sciences International, Hatfield, PA, USA) was performed according to the protocols specified in Table 1. In all protocols, the field of view (collimation) of the scan was equivalent to 6 cm. The tests were repeated four times for each protocol.

The median DAP and ESD values found for the four protocols are shown in Table 2. A significant difference ($p < 0.001$) was found among the four protocols for the two radiation dose assessment methods. The size of the voxel by itself did not influence the exposed radiation dose. When the exposure factors (TE, kVp and mAs) are maintained, simply changing the voxel size does not influence the radiation dose significantly. However, the protocols correlate the use of smaller voxels with greater milliamperage exposure times, which invariably increases the exposure dose.

Questions to the authors

1) Which of the image acquisition protocols you tested is the most cost-effective? Why?

Not only this but other studies have shown that the protocol using a 0.3 mm voxel offers a combination of good resolution and reduced radiation dose. It is therefore the most cost-effective.

2) Does the size of the field of view (FOV) used in Cone-Beam CT examinations influence the radiation dose?

Yes. Especially when it comes to kerma area product (KAP), which increases the probability of stochastic effects. However, in our study, no influence was observed because we used the same FOV in all incidences and measurements. But, for example, in CBCT scans with a reduced FOV or restricted to measurement levels by sextants, the dose received is significantly reduced, implying very specific indications.

3) Do studies of radiation dose with Cone-Beam CT pose any difficulties or limitations?

Yes, researchers are still seeking a dosimetric quantity and/or a methodology that allows CBCT exposures to be assessed in order to estimate stochastic effects and compare exposures with other technologies. This is only made possible thanks to the volumetric acquisition and advanced technology of CBCT equipment.

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