Skeletal dosimetry in cone beam computed tomography

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(Received 16 October 2008; revised 22 April 2009; accepted for publication 6 May 2009; published 9 June 2009)

Cone beam computed tomography (CBCT) is a relatively new patient imaging technique that has proved invaluable for treatment target verification and patient positioning during image-guided radiotherapy (IGRT). It has been shown that CBCT results in additional dose to bone that may amount to 10% of the prescribed dose. In this study, voxelized human phantoms, FAX06 (adult female) and MAX06 (adult male), are used together with phase-space data collected from a realistic model of a CBCT imager to calculate dose in the red bone marrow (RBM) and bone surface cells (BSCs), the two organs at risk within the bone spongiosa, during simulated head and neck, chest and pelvis CBCT scans. The FAX06/MAX06 phantoms model spongiosa based on micro-CT images, filling the relevant phantom voxels, which are 0.12x0.12x0.12 cm^3, with 17x17x17 mm^3 microvoxels to form a micromatrix of trabecular bone and bone marrow. FAX06/MAX06 have already been implemented in an EGSnrc-based Monte Carlo code to simulate radiation transport in the phantoms; however, this study required significant modifications of the code to allow use of phase-space data from a simulated CBCT imager as a source and to allow scoring of total dose, RBM dose and BSC dose on a voxel-by-voxel basis. In simulated CBCT scans, the BSC dose is significantly greater than the dose to other organs at risk. For example, in a simulated head and neck scan, the average BSC dose is 25% higher than the average dose to eye lens (~8.3 cGy), and 80% greater than the average dose to brain (5.7 cGy). Average dose to RBM, on the other hand, is typically only ~50% of the average BSC dose and less than the dose to other organs at risk (54% of the dose to eye lens and 76% of dose to brain in a head and neck scan). Thus, elevated dose in bone due to CBCT results in elevated BSC dose. This is potentially of concern when using CBCT in conjunction with radiotherapy treatment.

For download go to DOI: 10.1118/1.3147143