Evaluation of the Radiation Dose from Kilovoltage Cone Beam CT using Monte Carlo Simulation

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Purpose:
The purpose of this work is to investigate imaging radiation dose to the patient’s radiosensitive organs from a kilovoltage cone beam computed tomography (kV CBCT) scans using GATE Monte-Carlo simulation package.

Methods:
GATE was used to simulate the Varian OBI-CBCT system, and 4-D extended Cardiac-Torso (XCAT) phantom was incorporated into the simulation toolbox for the dosimetric study. CBCT scans in both full-fan and half-fan modes were studied and the default clinical CBCT beam characteristics of 125 kVp, 80 mA, and 25 ms were used in the study. Using this scanning configuration, we calculated dose distributions in the patient anatomies from a CBCT acquisition for different treatment sites, such as head-and-neck, and chest region.

Results:
Our results have shown that, from a typical head CBCT in full-fan mode, doses to soft tissues, such as eye, spinal cord, and brain were found to be 7.38, 7.59, and 7.92 cGy, respectively. For a body scan in half-fan mode, doses were calculated to be 6.33 (lung), 4.09 (heart), 5.90 (spinal cord), and 6.50 (soft tissue including skin) cGy. We also compared these values with the CTDIw data calculated from Ding et al (2009). They showed a good agreement.

Conclusions:
We have established a MC model of clinical OBI and validated its applicability to dosimetry. Our results provided accurate values of the additional doses to the normal tissues of a patient from a typical kV CBCT acquisition. The developed methodology using the GATE Monte Carlo beam calibration in this study would allow the user to precalculate both relative and absolute absorbed doses.

Acknowledgement: Financial support and help from others.