06) Theoretical investigation of the design and performance of dual energy x-ray detectors for kV and MV CBCT imaging in a radiotherapy treatment room

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PURPOSE
Integration of a kV x-ray source into the treatment head of a modern radiotherapy accelerator would facilitate geometric fusion of the CBCT images acquired using the MV treatment beam and the kV source. Such capability would offer many advantages, including improved integration and utilization of complementary imaging information as well as reduced hardware and maintenance. However, effective exploitation of this possibility would require x-ray detectors configured to provide high-DQE performance at MV energies, while preserving contrast, noise and spatial resolution at kV energies. A theoretical examination of the performance considerations governing the design of such detectors, based on matrices of optically isolated segmented scintillating BGO crystals coupled to active matrix flat-panel imaging arrays, is presented.

METHOD AND MATERIALS
Imaging performance of detector designs with scintillator thicknesses ranging from 0.25 to 2.0 cm and pitches ranging from 0.508 to 1.016 mm was examined. The calculations employed a hybrid Monte Carlo modeling technique based on radiation transport simulation coupled to optical Swank noise and blur determination. For each design, MTF and CNR for scintillator-array configurations involving front and back illumination were determined at 100 kVp and 6 MV.

RESULTS
Compared to conventional front illumination, back illumination provides very similar radiation transport results, but greatly reduced optical blur and Swank noise. With back illumination and a black reflector, CNR and MTF kV imaging performance is found to be largely insensitive to segmented scintillator thickness, permitting greater material thickness for MV x-ray detection. As thickness increases (and depending upon the pitch), while MV MTF decreases by ~45% to 50%, MV CNR increases by a factor ranging from ~2.7 to 2.8.

CONCLUSION
These initial results suggest the possibility of achieving dual energy x-ray imagers that exhibit CNR performance close to that of conventional treatment-room diagnostic imagers, while also providing over an order of magnitude improvement in CNR compared to that of existing megavoltage radiotherapy imagers.

CLINICAL RELEVANCE/APPLICATION
kV and MV image acquisition with a dual-energy detector and a kV source aligned with the treatment beam would precisely align volumetric information and facilitate improved precision in beam delivery.

FIGURE (OPTIONAL)
Uploaded Image

Disclosures:

Nothing to disclose: Larry Antonuk
Nothing to disclose: Langechuan Liu
Nothing to disclose: Youcef El-Mohri
Nothing to disclose: Hao Jiang
Nothing to disclose: Qihua Zhao

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