

AbstractID: 5118 Title: Evaluation of Scatter Mitigation Strategies for X-ray Cone-Beam CT

Purpose: Linac-mounted cone-beam CT (CBCT) imaging is a promising approach for improving the soft-tissue targeting accuracy of external-beam radiotherapy. However, the large proportion of signal due to scattered radiation results in large cupping artifacts and reduced contrast-to-noise ratio (CNR), hampering delineation of soft-tissue structures. The goal of this investigation is evaluate the impact of three scatter mitigation strategies: scatter removal (SR), subtractive scatter corrections (SSC), and anti-scatter grids (ASG) on CBCT image CNR.

Method and Materials: A one-dimensional model was developed that to predict image noise, intensity, and contrast from the photon flux incident upon the flat-panel detector. Using previously published scatter-to-primary ratio (SPR) data, the impact of Poisson signal statistics, Gaussian readout noise, reconstruction filter, and total air-kerma on image uniformity, contrast, and CNR was evaluated. Using previously measured CBCT scatter and primary grid transmission; the impact of ASGs, SSR, and SR (e.g., via bowtie filters) was evaluated. In addition, synthetic polyenergetic CBCT projections of cylindrical low-contrast threshold phantoms, including compound Poisson process noise, were used to evaluate the impact of scatter mitigation on filtered backprojection (FBP) images.

Results: Relative to complete SR, typical CBCT scatter reduces CNR by 30%–70% depending on patient diameter. Both 1D analysis and simulated images demonstrate that SSC effectively reduces cupping artifacts but does not improve CNR. ASGs with high scatter selectivity (>5) or large primary transmission (>0.7) modestly increase (20–30%) CNR for thick subjects. However, ASGs diminish CNR for smaller body sections or for exposure levels where additive noise dominates sinogram signal statistics.

Conclusion: Correcting CBCT sinograms for scatter radiation is effective in reducing structural image artifacts but does not improve CNR. Antiscatter grids effectively suppress scatter artifacts but improve CNR only in selected clinical settings. This project was supported in part by a grant from Varian Medical Systems.