Volume of interest cone beam CT with a low-Z linear accelerator target: proof-of-concept

In this work we employ a novel x-ray beam produced in a Varian linac by i) lowering the electron energy to 2.35 MeV and ii) installing a carbon target (7.6 mm thick) in the carousel. Low-Z target beams provide useful CNR characteristics for CBCT\(^1\)\(^2\) with a significant proportion of photons produced in the diagnostic energy range. A possible additional advantage of the approach is the availability of the MLC, which in concept should facilitate volume of interest (VOI) CBCT, whereby the MLC tracks a chosen VOI during gantry rotation. Here we explore a paradigm where a custom VOI is defined in the planning system following treatment planning (e.g., Figure 1). A dynamic sequence is generated where the MLC conforms to the VOI during CBCT acquisition. Because truncation of projection data produces marked artefacts following reconstruction, DRRs from the planning CT were produced at the angles of projections and used to fill missing data. Figure 2 demonstrates the efficacy of this approach in eliminating boundary and cupping artefacts in a lamb specimen. Dose distributions in a head phantom were measured to compare full-field and VOI techniques, using TLD800 dosimeters and EBT2 radiochromic film. Compared to full-field CBCT, inside the VOI, the dose is reduced by 5-15%, while outside of the VOI, the dose is reduced by as much as 75% (Figure 3). A small phantom containing water, bone and lung objects allowed measurement of CNR in low-Z CBCT images as a function of VOI dimension, however CNR was found to be approximately invariant for VOIs ranging in diameter from 4 to 15 cm (Figure 4). In summary, the low-Z target VOI method allows for imaging of selected volumes while localizing imaging dose, while the reduction of VOI dimension does not impact CNR.

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