Purpose: Respiration-correlated cone-beam CT (RC-CBCT) using slow continuous gantry rotation is commonly used to reduce respiratory motion blurring but image quality is limited by uneven projection spacing. This study investigates the efficacy of a novel gated CBCT technique (gantry motion and imaging only within gate) in reducing motion blur with improved image quality using a new type of computer-controlled linac (Varian TrueBeam).

Methods: For gated CBCT, the linac is programmed to gate gantry rotation and kV image acquisition with approximately 25% duty cycle around end expiration. The two-part study examines images in phantom and prospectively in patients with thoracic and abdominal tumors. A motion phantom is programmed to follow a patient respiratory trace (1.4cm mean excursion) and CBCT scans are performed in standard “free-breathing”, RC-CBCT, and gated CBCT modes. A standard CBCT of the stationary phantom serves as ground truth. Evaluation of phantom image quality compares contrast-to-noise ratios (CNR) of spheres embedded in acrylic, delineated on the static image and aligned to the other images. In patient studies, image fidelity in standard free-breathing and gated CBCT is compared relative to a respiration-correlated CT (RCCT) on the same day, by computing a cross-correlation metric (CCM) in an ROI around the internal target volume following rigid registration.

Results: CNR in motion phantom for gated CBCT is nearly that for static phantom (ratio gated/static 0.95) and larger than for RC-CBCT (ratio 1.64) and standard CBCT (1.22). CCM of the tumor ROI in gated CBCT is larger than standard CBCT in all three thoracic cases thus far (ratio gated/standard mean 1.04 range 1.03-1.06), indicating higher congruence with the ground-truth RCCT.

Conclusions: Gated CBCT visibly reduces image blurring caused by respiratory motion. By exploiting recent computer-controlled linac technology, complete projection sets can be acquired within a gate, yielding improved reconstruction image quality relative to RC-CBCT.