



How Low Can You Go? A CBCT Dose Reduction Study

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I. INTRODUCTION

Cone Beam CT (CBCT) is often used for patient set up based solely on bony anatomy. In these situations, there is a possibility to use an image acquisition protocol with lower kVp/mAs than routine clinical ones, thus lowering imaging dose. The goal of this work was to evaluate whether CBCT dose can be lowered to the level of kV image-pair doses when used for bony anatomy-based IGRT without compromising positioning accuracy.

II. METHODS

An anthropomorphic phantom was CT scanned in the brain, head and neck, chest, and pelvis regions and setup on the linear accelerator couch with the isocenter near the planned location. CBCT’s were performed with the standard “full dose” protocol supplied by the linac vendor. With sequentially lowered dose, 3D matching was performed for each without shifting the couch. The mAs, kVp, and frame rate were lowered from standard protocols to achieve the lower doses. The standard kV-pair protocol for each site was also used to image the phantoms and 2D-2D auto matching was similarly performed. For all studies, 6 degrees of freedom were included in the 2D or 3D matching to the extent they could be employed. Imaging doses were determined in air at isocenter following the TG-61 formalism.

III. RESULTS

CBCT dose was reduced to nearly that of the standard kV image pair dose for each site. That represented a reduction by 81-98% of the standard CBCT protocol dose. Relative to the standard CBCT shift values, translational shifts for the reduced dose CBCT were within 0.2mm for all sites, while shifts were slightly larger than that for the kV-pair, being within 1.5mm across all sites. Rotational shifts were within 0.1 degree for the reduced dose CBCTs for all sites while the kV-pair produced relative rotations of up to 1.7 degrees. The results are tabulated in table 1.

| Head | Low dose CBCT vs. | kV/kV vs. |
|------------------------------|-------------------|----------------|
| Shifts (cm/degree) | Full dose CBCT | Full dose CBCT |
| Vert | -0.01 | -0.15 |
| Long | 0.00 | 0.02 |
| Lat | 0.00 | -0.04 |
| Rtn | -0.10 | 0.70 |
| Pitch | 0.10 | -0.40 |
| Roll | 0.00 | -1.70 |
| Imaging dose @iso | 0.11 | 0.07 |
| Full dose CBCT imaging dose: | 0.57 | |

| Head & Neck | Low dose CBCT vs. | kV/kV vs. |
|------------------------------|-------------------|----------------|
| Shifts (cm/degree) | Full dose CBCT | Full dose CBCT |
| Vert | 0 | 0 |
| Long | 0 | -0.01 |
| Lat | 0.01 | 0.02 |
| Rtn | 0 | -0.1 |
| Pitch | 0 | 0 |
| Roll | 0.1 | 0.3 |
| Imaging dose @iso | 0.05 | 0.06 |
| Full dose CBCT imaging dose: | 0.57 | |

| Chest | Low dose CBCT vs. | kV/kV vs. |
|------------------------------|-------------------|----------------|
| Shifts (cm/degree) | Full dose CBCT | Full dose CBCT |
| Vert | 0.02 | 0.02 |
| Long | 0 | -0.05 |
| Lat | 0.01 | 0 |
| Rtn | -0.1 | -0.1 |
| Pitch | -0.1 | 0 |
| Roll | -0.1 | 0.1 |
| Imaging dose @iso | 0.08 | 0.08 |
| Full dose CBCT imaging dose: | 1.87 | |

| Pelvis | Low dose CBCT vs. | kV/kV vs. |
|------------------------------|-------------------|----------------|
| Shifts (cm/degree) | Full dose CBCT | Full dose CBCT |
| Vert | 0.00 | -0.03 |
| Long | -0.01 | 0.00 |
| Lat | 0.00 | 0.04 |
| Rtn | 0.10 | -0.40 |
| Pitch | -0.10 | -0.60 |
| Roll | 0.10 | 0.30 |
| Imaging dose @iso | 0.16 | 0.13 |
| Full dose CBCT imaging dose: | 6.77 | |

Table 1: The results of comparison of shifts and the imaging dose reduction for the four sites

IV. CONCLUSIONS

For bony anatomy-based image guidance for a wide range of anatomical sites, it is possible to reduce the CBCT dose to a value similar to that of kV image pairs with similar or better patient positioning accuracy. Where rotations are important to correct, CBCT will be superior to orthogonal kV-pair imaging without significantly increased imaging dose. This is especially important for image guidance for pediatric patient treatments.