PhD Thesis Title: Accurate Tracking of Position and Dose During VMAT Based on VMAT-CT

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ABSTRACT:

Purpose: Local tomography reconstruction is achievable with Electronic Portal Imaging Device (EPID) images that are acquired during Volumetric Modulated Arc Therapy (VMAT) and it was named VMAT-CT. However, it did not gain popularity due to various limitations and technical challenges. The goal of this study was to extend the Volumetric Modulated Arc Therapy-Computed Tomography (VMAT-CT) concept, generate complete 3D or 4D CT images and dose, track and adapt the VMAT plan based on updated images and dose.

Methods: We considered using the collimator angle and removed the blurred areas in the EPID images for VMAT-CT reconstruction to reduce the artifacts and improve the image quality. "VMAT-CT+" images were generated by fusing the VMAT-CT with the planning CT using a rigid or deformable registration. For the 4D Stereotactic Body Radiation Therapy (SBRT) VMAT, the breathing signal was extracted from the EPID images which were sorted into four phases, then the dose was calculated in each phase and registered to the mean position of the planning CT to generate 4D composite dose. The doses were based on the VMAT-CT+ and the Cone Beam Computed Tomography (CBCT). They were prepared for phantoms and real patients. When the prescribed dose coverage was not met for the planning target volume (PTV), re-planning was performed on the phantoms. The possible uncertainties were also evaluated.

Results: Tracking based on VMAT-CT+ was more accurate and superior to that based on CBCT since VMAT-CT+ can detect changes after setup. VMAT-CT could accurately detect the phantom deformation and changes in the breathing pattern. Re-planning based on VMAT-CT improved target coverage in both 3D and 4D cases. For real patients, the dose that was based on VMAT-CT agreed well with that based on CBCT acquired on the same day. The impact of uncertainties on the dose was minimal for both 3D and 4D cases.

Conclusion: The 3D and 4D tracking and adaptation of the VMAT based on VMAT-CT were feasible. Our study can be incorporated into the patients' daily routine and has the great potential to increase the confidence of beam delivery, and catch-and-remedy errors during VMAT delivery.

References to author publications that relate specifically to the dissertation:

1. **Zhao, Xiaodong**, and Rui Zhang. "Feasibility of 3D tracking and adaptation of VMAT based on VMAT-CT." *Radiotherapy and Oncology* (2020). DOI: 10.1016/j.radonc.2020.04.032