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# SBRT on Halcyon Linear Accelerator: Exploring Dosimetric Impact of Residual Rotational Error after Correcting for Translational Setup Errors

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**Abstract**
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## Abstract

Objective: Halcyon O-ring LINear ACcelerator (Linac) has become an increasingly utilized treatment platform in radiation therapy, and previous dosimetric studies have shown similar plan quality (up to 1-cm PTV) for Stereotactic Body Radiation Therapy (SBRT) compared to traditional C-arm linacs. However, the Halcyon couch system is limited to 3D translational correction only, and therefore cannot correct for residual rotational errors post translational alignment. Currently there is no established quantifications or clear practice guidelines of the dosimetric impact on this platform. In this study, we developed a simulator to determine the dosimetric effects of rotational error on target coverage and Organs At Risk (OARs) doses. Plan robustness was evaluated for multiple levels of rotational perturbations for typical clinical sites.

Methods: A rotational simulator along three orthogonal axes was developed using the open-source software 3DSlicer. The required inputs of the simulator include 3D CT images and the location of plan isocenter. Any degree of rotation along either axis can be performed. 15 spine and 15 liver SBRT patients were retrospectively planned on the Halcyon by experienced planners following clinical prescriptions. Dose deviations due to rotational setup errors were investigated by simulating 1-degree and 2-degree rotations in the pitch, yaw, and roll directions and recalculating target coverage and OAR doses.

Results: With 1-degree rotation in either pitch, yaw or roll, target coverage D95% deviated by -0.22% for liver SBRT (range from -3.3% to 1.7%), and 0.43% for spine SBRT (range from -3.6% to 2.8%) from the nominal plan value. The volume of liver receiving <1500 cGy varied by 0.31% for liver SBRT (range from -1.1% to 1.4%), and the maximum dose to the spinal cord varied by 1.26% (0.18Gy) ranging from -1.3% to 7.0% (-0.16Gy to 1.07Gy) for spine SBRT. Similar experiments were carried out for 2-degree rotation, where D95% varied by 0.43% for liver SBRT and 0.86% for spine SBRT. The volume of liver receiving <1500 cGy varied by 1.02% for liver SBRT and the maximum dose to the spinal cord varied by 3.69% (0.52Gy) ranging from -2.55% to 15.89% (-0.25Gy to 2.46Gy) for spine SBRT.

Conclusion: A simulator for rotational setup errors was developed for Varian Halcyon Linac based on an open-source platform. Rotational residual setup errors result in minimal dose deviations when limited to 1 degree, indicating the importance of designing and implementing alignment procedure to evaluate and limit setup rotational errors to <1 degree prior to treatment for SBRT on Halcyon.