

Modeling Radionecrosis with Variable Margins After Single Isocenter Automated VMAT Radiosurgery

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Abstract

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Abstract

Objective: Due to potential dosimetric error associated with rotational error of multiple target single isocenter radiosurgery, many centers add 1-3 mm PTV margins. To better define the additional toxicity of these small margins, we propose a model based upon a large clinical dosimetry dataset.

Methods: Single isocenter multiple target VMAT radiosurgery has been practiced at one center with a Varian 6DOF couch with zero margin added to GTVs. A quality assurance database containing all DICOM plan objects since implementation of automated single isocenter planning (HyperArc™) beginning in 2017 was queried for V12Gy for various tumor volumes with scaling of the plan for nominal prescription of 18Gy. Plans with bridging of the 50

% isodose line due to proximity of tumors were excluded. The final dosimetry model included 496 plans and 1332 targets. The output of this model produced V12Gy for tumors 5-40 mm diameter including theoretical volumes corresponding to 0-3 mm margins. The risk of radionecrosis was estimated from the HyTec publication by Milano et al (IJROBP 2021) using the V12Gy model.

Results: V12Gy increased according to diameter and margin resulting in a progressive risk of radionecrosis. For 1 mm margin the increase in V12Gy varied from 0.34 cc (5 mm diameter) to 15.86 cc (40 mm diameter). For 2 mm margin the increase in V12Gy was 0.95 cc (5 mm diameter) to 33.3 cc (40 mm diameter). NTCP (radionecrosis) worsened by equivalent diameter (or volume) and with increasing margin. Example calculations for a 2 mm margin predict a relative increase in toxicity of 13-66% for tumors 10-40 mm in diameter.

Conclusion: This model of single isocenter multi-target dosimetry predicts clinically significant risks in toxicity with added margins. The decision to add a margin should include both the risk of underdosing tumor and the added risk to normal tissue. Frameless radiosurgery programs should develop processes to minimize margins. HyTec estimates predict that hypofractionation does not eliminate the increased risk of margins.