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Abstract
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Dosimetric Comparison of Hyper Arc Single-Isocenter Multi-Target and Gamma Knife Based Stereotactic Radiosurgery for a Patient with 53 Brain Metastases

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Abstract

Objective: An estimated 20% of patients with cancer will develop brain metastases during their lifetime. Stereotactic radiosurgery (SRS) has become a preferred method for managing limited metastasis, while its role in managing numerous metastases is less clear but of increasing interest. SRS options include multi-isocenter techniques like Gamma Knife (GK) & single-isocenter LINAC SRS, each of which can deliver high-quality plans. In this study, a patient with 53 melanoma brain metastases received single-iso LINAC SRS was retrospectively replanned with Gamma Knife to assess the differences in plan quality for this type of scenario. We compared the dosimetry and delivery efficiency of both plans.

Methods: The treating team used HyperArc to develop the single-isocenter LINAC SRS plan in Eclipse v15.6 (Varian Medical Systems), with 53 targets. We later created a second GK plan with Gamma Plan v11.3.1 lightning optimizer. For comparison, all targets were normalized so that for a prescription of 18Gy, V100%≥95%. The mean target size was 0.19 cc (range 0.01-6.03 cc). We compared the following metrics between the two plans: plan conformity (RTOG & Paddick), plan R50, V12Gy, V5Gy, mean dose to healthy brain, and hippocampal dmax/D100. We also compared the time spent generating the plan and the treatment delivery time.

Results: Median V100% was > 99% for both HyperArc and GK plans. Overall plan conformity for HyperArc plan was 1.37 (RTOG) / 0.68 (Paddick). Overall plan conformity for GK was 1.67 (RTOG) / 0.60 (Paddick). Plan R50 for the HyperArc plan was 20.69, while for GK was 6.71. For individual lesions without dose overlap with adjacent lesions, the median value for individual target RTOG CI was 2.2 (range 1.05-4.32) and 1.64 (range 1.16-3.04) for HA-VMAT and GK, respectively, which are comparable. Total plan V12 for all 53 mets was 69.3cc for HyperArc and 36.7cc for GK. No contiguous region of V12 was greater than 10cc for either plan. Total plan V5 was 911.6cc for HyperArc and 283.3cc for GK. Mean healthy brain was 6.64Gy for HyperArc and 2.83Gy for GK. Hippocampal dmax (not specifically spared in either cost function) was 22.7Gy for HyperArc and 30.1Gy for GK; hippocampal D100% was 5.31Gy for HyperArc and 3.55Gy for GK. Planning time was < 30 minutes for both techniques. Treatment time was 6.5 minutes for HyperArc and 412 minutes for GK.

Conclusion: This study compared the plan quality and delivery efficiency of a patient treated with SRS for 53 mets with HyperArc to a retrospective Gamma Knife replan using a modern inverse-planning tool. We observed notable differences between the two plans with the apparent limitation caveat that it is a single case. The HyperArc plan exhibited better conformity and hippocampal dmax, implying better normal tissue dose-volume characteristics at the high dose levels near and above the prescription dose. In contrast, the Gamma Knife plan exhibited better V12, V5, mean brain, hippocampal D100, implying better normal tissue dose-volume characteristics for the moderate and low isodose levels. The Gamma Knife plan required much longer to be delivered than the HyperArc plan. As interest continues to grow in using SRS for patients with large numbers of metastases, understanding, improving, and leveraging the different capabilities of different planning and delivery systems in these clinical scenarios will become increasingly important.