Planning and Delivery Performance of the Halcyon™ Platform for Multiple Small Targets with a Single Isocenter

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Introduction

Numerous studies have reported on the safety and effectiveness of stereotactic radiosurgery (SRS) for the management of brain metastases, leading to a gain in popularity throughout the radiation oncology community. The relatively recent development and advancements of high-precision treatment delivery systems and image guidance has expanded the availability of SRS to linac-based radiation therapy centers. The use of volumetric modulated arc therapy (VMAT) with high-definition multileaf collimators (HDMLC) has further improved the accuracy and conformity of SRS, especially when treating multiple cranial metastases with a single-isocenter treatment.

A new type of linac has recently been introduced by Varian Medical Systems (Palo Alto, CA), named Halcyon™, that exhibits a number of advantages over more traditional c-arm linacs. These include 4 times faster gantry rotation speed, ring-shaped enclosures to eliminate collisions, and new type of dual layer MLCs. The Halcyon™ MLCs exhibits a travel speed that is twice as fast as existing MLCs, reduced leakage, improved penumbra, and smaller dosimetric leaf gap (DGL). This improved MLC design, along with an improved treatment workflow and 6FFF capabilities, makes the Halcyon™ a potentially favorable treatment unit for multi-met SRS treatment.

Methods

10 patients, each with 6-10 cranial metastases with volumes ranging from 0.11-8.57 cc and prescription doses from 15-24 Gy, were retrospectively studied. The clinical plan for each patient was generated with multi-aperture dynamic conformal arc (DCA) with non-coplanar beam arrangement. Additional plans were generated with Halcyon Version 1 with coplanar arcs, Halcyon Version 2 with coplanar arcs, HDMLC with coplanar arcs, and HDMLC with non-coplanar arcs. Standard cranial treatments typically make use of non-coplanar beam arrangements, but the coplanar HDMLC arrangement was chosen to serve as a direct MLC comparison as the Halcyon is currently only capable of coplanar arrangements. All same-case plans were generated with the same planning protocol and normalization. Plans were evaluated based on Conformity Index (CI), Gradient Index (GI), V12Gy, V6Gy, V3Gy, and brain mean dose.

Dose Spillage and Planning Efficiency

Table 1: Mean and standard deviation values of per target parameters for different planning techniques. Values shown were generated using CI and GI from the corresponding techniques indicated in the top row minus the technique indicated in the left most column. A bold text indicates statistical significance found between the corresponding techniques using Wilcoxon Signed Rank test.

Dose Distribution Comparison

The dual-layered stacked and staggered MLC design implemented in the Halcyon has shown to effectively conform to small targets with a diameter >5 cm. However, for targets with a <5 cm diameter, the limitation of coplanar beam arrangements on the Halcyon leads to inferior plan quality compared to non-coplanar treatment on a c-arm linac with HDMLCs.