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CyberKnife MLC Planning for Multiple Brain Metastases Stereotactic Radiosurgery: A New Treatment Planning Approach

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Abstract

Objectives: The American Society for Radiation Oncology guidelines for management of brain metastases (mets) suggests stereotactic radiosurgery (SRS) to be the primary treatment choice for multiple mets (multimets) when quality of life is considered as the most important outcome. Recently developed approach, HyperArc VMAT planning, fulfill the demands of treating multimets with SRS. Here, we present the competitive planning treatment approach of stereotactic treatment of multimets with Cyberknife (CK) MLC collimator using voxel-less optimization (VOLO).

Methods: SRS planning was carried out for 10 brain multimet patients with the number of mets ranging from 4-15. The treatment planning process was carried out with a Precision 2.0 TPS and VOLO optimization algorithm. Ray tracing algorithm was utilized for all calculations due to homogeneous brain density. All plans were setup with head_MLC treatment anatomy, full path set and 6D tracking method. The beam direction was set to never intersect with OAR eyes. The initial parameter of the plan included the setup of fluence smoothness penalty (1), total MU penalty (1-5), number of MUs per beam (500-750 MUs) and per node (600-900 MUs), setting upper bonding constraint for the PTV, PTV coverage goal, and the restriction of the dose fall achieved with constraining the dose to shells. To keep reasonable treatment times (< 1 hours), MU penalty was increased to 5 for plans with number of lesions more than 10. On average, three shells around the target were generated with sharp dose gradient objectives. Prescription (Rx) doses varied from 2000cGy to 2200 cGy. Dose streaking of more than 30% of Rx dose was prohibited. Total treatment times and total monitor units (MUs) of all plans were analyzed. In addition, dosimetric parameters for PTV, such as homogeneity index (HI) (HI=Maximum Dose/Rx Dose), conformity index (CI) (CI= Rx volume (V)/target V); gradient index (DGI) (Wagner et al., Int J Radiat Oncol Biol Phys. 2003;57:1141) and predictive radionecrosis V12Gy were investigated.

Results: CK MLC treatment approach for planning multimets in a single plan resulted in reasonable treatment times of less than an hour. The average treatment times were 37 min (4-7 mets), 46 mins (8-12 mets) and 57 min (12-15 mets). The average total MUs increased with number of lesions and were 17474 (4-7 mets), 22427 (8-12 mets) and 27545 (12-15 mets). The HI was similar across all plans and the average HI was 1.25?±?0.04. CI was 1.11 ±?0.03 for most of the plans and raised to 1.33 ±?0.09 for the multimets with single V met < 0.2 cc. Plans for 4-8 lesions met DGI guidelines set at our institution, and for higher number of mets, around 50% of

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lesions failed DGI criterion. Lastly, average V12Gy was 7.9 Gy (4-7mets), 18.9 Gy (8-11mets) and 37.2 Gy (12-15 mets).

Conclusions: Feasibility of treating multimets with CK MLC platform was presented. CK MLC plans for less than 10 mets showed short treatment times and provided very high conformity, rapid dose falloff and low V12Gy values. We don't recommend treating very small mets (V<0.2 cc) with CK MLC due to leaf width penumbra resulting in higher CI and V12Gy values; fixed cones are better suited for sharper dose fall-off. Number of lesions treated in a single plan would have to factor in treatment time, gradient index for each lesion as well as normal brain V12Gy, & patients age and cognitive status. We propose using multiple plans if the number of lesions is greater than 10.