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Treatment of Multiple Brain Metastases: Non Isocentric Robotic vs. Single Isocenter Modulated Arc Radiosurgery

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Abstract

Objectives: Stereotactic radiosurgery (SRS) plays a role as an important treatment modality for patients with multiple brain metastases. The purpose of this study is to evaluate the relative plan quality of robotic radiosurgery vs single-isocenter volumetric modulated arc therapy (Vmat) for radiosurgical treatment of multiple brain metastases.

Methods: 11 patients with 36 brain metastases were selected for this study. All patients were scanned with 1 mm slice thickness in supine position with thermoplastic mask. All critical structure were contoured according to RTOG guidelines. The maximum target diameter, as determined by T1-weighted contrast-enhanced magnetic resonance imaging (MRI) and CT, was <3.5 cm in all patients. The gross tumor volume (GTV) for each lesion was defined by a radiation oncologist and planning target volumes (PTVs) for each lesion were generated by adding a 1-mm margin to each GTV. Composite target was established by combining each individual PTV. All patients were treated in a single fraction with median dose 17 Gy (16-18 Gy). For every patient single isocentric Vmat plans were generated using Eclipse treatment planning system. The isocenter was not placed over an individual lesion but placed over a geometric center of all PTVs. 2-4 arc was used and calculated with Analyltical Anisotropic Algorithm with 1 mm grid size in all plans. Beam energy was 6FFF or 10FFF and MLC leaf thickness was 2.5 mm in all Vmat plan. All plans were normalized to deliver minumum 95% of the prescription dose. Robotic radiosurgery (CK) plans were created using Multiplan 5.1 treatment planning system with 6FFF beam and fix cones. All plans were non-isocentric and non-coplanar. Mean number of beam were 165 (102-195). Typical dose constraints were as follows: brainstem, optic pathway (optic chiasm, optic nerves, and eye) <8 Gy, and lens <2 Gy. Dose to normal brain was not constrained but brain-PTV was calculated for each patient. Treatments were delivered with Truebeam 2.0 and Cyberknife M6. Conformality Index (CI) was calculated both by Paddick and RTOG formula. Additionally, each plan was calculated by an overall Paddick gradient index (GI).

Results: All plans were evaluated and approved by medical physicist and radiation oncologist. Mean PTVmin, PTVmax, PTVmean values for Vmat and CK plans were 95%,119%,108% and 95%,120.5%,110.8%,respectively. Slight differences were seen in the maximal, minimal, and mean doses for all plans. CK plans had a greater mean dose than Vmat plans. Mean CI for Vmat and CK plans were very similar. Mean Paddick and RTOG CI were 0.721 and 1.43 for Vmat plans,

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0.712 and 1.41 for CK plans, respectively. Paddick GI were 4.76 and 4.69 for Vmat and CK plans. Significant differences was observed in mean beam-on time between these two plans. Mean treatment times were approximetely 5 times shorter in Vmat than CK plans. Normal brain dose receiving 12Gy(BD12Gy), 10Gy(BD10Gy) and 8Gy(BD8Gy) were evaluated in each plan. For Vmat plans, mean BD12Gy, BD10Gy,and BD8Gy were 1.54%,2.41% and 3.78% respectively. For CK plans, mean BD12Gy, BD10Gy,and BD8Gy were 1.74%,2.53% and 3.83% respectively. Mean optic pathway doses were lower in CK than Vmat plans (0.46 Gy Vs 2.71 Gy). Mean brain stem dose were 4.55 Gy and 2.06 Gy in Vmat and CK plans, respectively.

Conclusions: Both robotic radiosurgery and single isocenter Vmat plans with 2-4 arcs can produce highly optimal dose distributions for patients with multiple brain metastates.