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Abstract

Evaluation of a Novel Streamlined Solution for MLC-based Intracranial SRS

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Objectives: To evaluate the planning workflow and delivery for HyperArc and to compare the results with conventional Rapid Arc stereotactic radiosurgery (SRS).

Methods: Nine VMAT plans were used to compare the plan quality and workflow for HyperArc and conventional Rapid Arc SRS. Two types of plans were created, one using an anthropomorphic head phantom and 7 clinical plans, selected for different locations, number of targets and target sizes. Four of the plans treated a single lesion plans while the other 5 treated multiple lesions. The simulation was performed on a GE CT scanner using a slice thickness of 1.25 mm. The clinical plans have been previously treated using a Varian TrueBeam linac with same beam angles (1 coplanar and 3 non-coplanar beams) and were re-planned using the HyperArc module using PO 15.6 VMAT optimization algorithm. Isocenter position, collimator angles and jaw positions were optimized using the optimizer included in the HyperArc planning module and virtual dry-runs were performed to prevent collisions. The planning strategy for conventional Rapid Arc plans included the use of control ring structures, while for HyperArc the SRS normal tissue objective (NTO) available for the Eclipse Photon Optimizer version 15.6 was used. The normalization for all plans was such that the isodose volume for 100% of the prescribed dose covered 98 % of the target volume. Patient-specific QA was performed for all plans using EPID portal dosimetry. Additionally, for two of the HyperArc plans, a phantom-based measurement was performed comparing the dose predicted by the treatment planning system with the dose measured using a pinpoint chamber and EBT XD film. QA measurements were performed on a water equivalent elliptical phantom (CIRS, model 002H5).

Results: The commissioning of HyperArc has been successfully completed from the CT-sim to the beam delivery. The IMRT factors, calculated as the ratio of the MUs to the tumor dose were 2.7±0.6 and 3.0±0.7 for the conventional and HyperArc plans, respectively. Maximum doses ranged from 126.1% to 136.9% for the original plans and from 124.5% to 168.4% for HyperArc. The conformity index (CI) for all the single-lesion plans was less than 1.18 for the original plans and 1.05 for the new plans. For multi-met cases CI values increased up to 1.89 and 1.68 for the original and HyperArc plans, respectively. The most significant difference between conventional and HyperArc plans was observed in the gradient measurement (GM), which was 0.62±0.18 for the original plans and 0.49±0.16 for the HyperArc plans. QA results of HyperArc plans using phantom based measurement and portal dosimetry passed within the department QA tolerance (3% dose/3mmDTA criteria and 10% threshold dose level). The Pass rate of Gamma test of HyperArc plans are comparable with conventional RapidArc SRS.

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Conclusions: HyperArc provides a number of advantages that simplify the planning and delivery of SRS plans. The HyperArc planning module allows for automatic isocenter location, collimator angle and jaw opening simplifying the planning process especially for multiple-lesion treatments. Patient safety is ensured by means of the virtual dry-run of the treatment fields. The plan quality for HyperArc plans showed improved values of CI and GM, and higher values for the maximum dose were observed. The RTOG CI, Paddick CI and ICRU HI are included in the HyperArc plans dose statistics allowing for a more comprehensive plan evaluation.