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Abstract

Evaluation of Clinical Plan Quality Based on Dosimetric Indices for A Novel Stereotactic Radiosurgery System

Dilini Pinnaduwage [1] , Shiv Srivastava [2] , Shyam Jani [3] , Xiangsheng Yan [1, 2] , Stephen Sorensen [4]

1. Neuro-Radiation Oncology, Barrow Neurological Institute, Phoenix, USA 2. Neuro-Radiation Oncology, Barrow Neurolo, Phoenix, USA 3. Neuro-Radiation Oncology, Barrow Neurological Institute/St. Joseph's Hospital and Medical Center, Phoenix, USA 4. Radiation Oncology, St. Joseph's Hospital, Phoenix, USA

Corresponding author: Dilini Pinnaduwage, dilini.pinnaduwage@dignityhealth.org

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Objectives: The first clinical ZAP-X (ZAP Surgical System Inc., San Carlos, CA) self-shielded radiosurgery was installed at our institution in late 2018. Here, we retrospectively report on treatment planning metrics based on clinical plans that were generated for the first 30 intracranial stereotactic radiosurgery treatments.

Methods: For each clinical case, a planning CT with 1-mm slice thickness was acquired. A 1-mm slice thickness MR (+C SPGR) image dataset was co-registered to the CT and used for target volume and organs-at-risk (OARs) delineation. Images were co-registered in the CyberKnife (Accuray Inc., Sunnyvale, CA) treatment planning system (TPS), and target volumes and OARs were delineated and verified by both a Radiation Oncologist and Neurosurgeon. The planning target volume (PTV) was generated by a 1mm uniform expansion of the gross target volume (GTV) unless the GTV was adjacent to a critical structure (e.g. brainstem, optic structures). The CT, fused MRI, and RT structures were DICOM imported into the ZAP-X TPS. This approach was best suited for our clinic during the initial stages of using the ZAP-X TPS. The ZAP-X TPS currently allows for isocentric (source-to-axis distance (SAD) = 45 cm) forward planning with eight fixed collimator sizes available for planning: 4, 5, 7.5, 10, 12.5, 15, 20 and 25mm. Isocenters of varying sizes were chosen based on target shape, size, and proximity to critical structures. The weighting for each isocenter was modified to achieve a conformal dose distribution. Although the ZAP-X system allows for 260+ non-coplanar beam angles, a customized beam path (a subset of the total available beam angles) was used for each patient plan based on the target location to eliminate potential collisions and to reduce path traversal time during treatment delivery. For some treatment plans, a combination of two beam paths (e.g. one path with more beams (~70-80) and one path with a smaller subset (~30)) was used. The ZAP-X TPS uses a Ray Tracing algorithm for dose calculation. Either a 0.5 or 1.0 mm dose grid was used for calculation. The prescription (Rx) dose was assigned to the isodose line which best conformed to the target volume. Rx doses ranged from 13-20 Gy for single fraction, and 25-30 Gy for five fraction treatments. For each plan, the Conformity Index (CI = Rx isodose volume/target volume), Normalized Conformity Index (nCI = Rx isodose volume*target volume/(target overlapping Rx isodose volume)2), Gradient Index (GI = volume of 50% of the Rx isodose line/Rx isodose volume), Homogeneity Index (HI = maximum dose/Rx dose) and Selectivity (target overlapping Rx isodose volume/Rx isodose volume) were calculated.

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Results: The average target volume treated was 2.9 cc (range: 0.03-28.3 cc). Rx isodose lines ranged from 50-80% and average target coverage was 98.8% (range: 93.5-100%). On average, 4 isocenters (range: 1 -13 isocenters) and 213 beams (range: 30-638) were used per plan, with a typical beam path comprising of 52 beams (range: 28-90). Plan conformity was 1.84 (range: 1.11-5.03) and 2.13 (range: 1.16-6.34) based on CI and nCI metrics, respectively. The GI was 3.05 (range: 2.41-4.16) and selectivity was 0.59 (0.2-0.88). Monitor Units per plan was 11459 (range: 3606-33697), yielding an average IMRT factor of 6.4 (range: 2-17.7).

Conclusions: Dosimetric indices for ZAP-X treatment plans are similar to those that can be achieved with other isocentric, forward planning SRS systems.