

Determining the Spatial Accuracy of Frameless Linac-Based Radiosurgery for Trigeminal Neuralgia

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Abstract

Objectives: To determine the spatial accuracy of frameless linac-based radiosurgery for trigeminal neuralgia.

Methods: We used two different phantoms to measure spatial and dosimetric accuracy of a frameless SRS treatment for trigeminal neuralgia. The first phantom was created using a 3D printer to construct an anatomically accurate hollow phantom using a patient's DICOM images. The phantom was filled with a polymer gel dosimeter. The gel's characteristics are such that it changes its chemical behavior in proportion to the dose absorbed. These changes can be detected under specific MRI sequences. The actual patient treatment plan, consisting of 7 non-coplanar arcs and delivered with a 4 mm cone, was irradiated onto the phantom. We molded an SRS mask for the phantom, and used a kV-kV positioning system to verify positioning between arcs. The phantom was subsequently scanned by MRI using predefined pulse sequences to generate high spatial resolution 3D T2 maps. These maps were then converted into 3D dose distribution measurements that were co-registered to the real patient planning CT images, RT structures, and TPS calculated dose data.

The second phantom was a commercial SRS head phantom with accurate bony anatomy and interchangeable inserts for diodes, ion chambers and films. We irradiated this phantom with the same plan, once using a diode for total dose measurement, and once with high dose (up to 100 Gy) gafchromic film for spatial resolution.

Results: For the 3D phantom, relative dose profiles through the target volume for measured and TPS-calculated datasets were compared. Our results showed an agreement of better than 1mm throughout the various profiles.

2D gamma comparisons were also performed with passing criteria of 2mm distance to agreement and 5% dose difference for selected slices of the phantom. We obtained better than 98% pass rate on all slices.

DVH comparisons for planned and measured relative dose distributions for PTV and trigeminal nerve were calculated. Doses were normalized to 100% corresponding to the dose received by at least 50% of the volume for each structure. Mean PTV dose was 98% vs 97% for TPS vs measured dose and D95% was 16% for both measured and TPS dose for the trigeminal nerve.

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For the second phantom we achieved a dose accuracy of 2%, and a spatial accuracy of 0.4mm.

Conclusions: Frameless linac-based radiosurgery with a 4 mm cone can be highly spatially accurate if delivered carefully, with use of appropriate imaging between arcs. End-to-end verification of accuracy is necessary to ensure quality of treatment at least as part of implementation of a high dose, high accuracy SRS program.