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3-D Optical Tomography Using CMOS Camera Provides Accurate Central Axis Data for Small SRS Cones

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Abstract

Objectives: Proper characterization of small fields used in stereotactic radiosurgery has been challenging. Lack of lateral electronic equilibrium, volume averaging & fluence perturbation due to non-water equivalent detectors has resulted in erroneous measurement of critical dosimetric quantities. Moreover, due to small beam apertures, detector orientation and placement becomes critical & finding the true central axis becomes cumbersome. These factors have resulted in dose misadministration in the past. Previously, optical imaging was used to image 2D- projected dose distributions for small static beams and VMAT plans [1]. Although the technique showed good agreement with the treatment planning software, one major drawback was that the technique was limited to a projected 2D visualization of the dose, thereby losing information about important quantities such as central axis percentage depth dose (Pdd), cross beam profiles (Cbp) and output factors. In this study, we use optical imaging in conjunction with filtered-back projection to reconstruct a 3D view of small conical SRS beams.

Methods: A rectangular 40cm x 30cm x 30cm water phantom was doped with 1g/L quinine sulfate and used as the dose deposition medium. Optical photons produced via scintillation and Cherenkov radiation were captured using an intensified time-gated (CMOS) camera (C-Dose, DoseOptics LLC., Lebanon, NH). Varian's TrueBeam equipped with SRS conical applicators and a beam energy of 6MV FFF was used for this study. A reference 10cm x 10cm field and a small conical 5mm beam were imaged. Multiple views of the beam were provided by rotating the collimator at increments of 2 degrees. At each angle, a total of 100MU were delivered. Finally, the different projected views of the beam were used to construct the 3D dose volume of the static beams via filtered back projection. Using the reconstructed 3D volume, important central axis dosimetric quantities were extracted and compared to the base line commissioning data.

Results: With the camera 2m away from the iso-center, we were able to achieve a pixel size of 0.2mm/pixel and a spatial resolution of 1mm. Central axis Pdd and Cbp, for the reconstructed 10cm x 10cm beam, when compared to the commissioning data, exhibited a passing rate (1D Gamma criteria of 3%/1mm with global normalization) of 97% and 92%, respectively. Most failing points were concentrated around the shoulder and penumbra region of the crossbeam profile. For the 5mm conical beam, central axis Pdd and Cbp showed a passing rate of 95% and 94%, respectively when compared to the commissioning data. For the 5mm Cbp, most of the

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failing pixels were again found in the penumbra region.

Conclusions: Due to steep dose gradients, AAPM TG 101 recommends that a detector with a spatial resolution 1mm or better be used for small fields. Therefore, with a resolution of 1mm, the technique is a promising candidate for small field dosimetry. The technique was able to successfully replicate commissioning data for the 5mm cone. Moreover, the sensing volume in this technique is the entirety of the water phantom; this makes detector placement less critical for small fields. The above-mentioned reasons make this technique an attractive candidate for accurately measuring output factors for small fields. 1) Ashraf, Muhammad Ramish, et al. "Optical Imaging Provides Rapid Verification of Static Small Beams, Radiosurgery and VMAT Plans with millimeter resolution." Medical physics (2019).