Commissioning and Implementation of Monte Carlo Independent Dose Calculation for Single Isocenter Multiple Target VMAT Radiosurgery

Justus Adamson, PhD - Duke University; Brett G. Erickson - Duke University; Yunfeng Cui, PhD - Duke University; Chunhao Wang - Duke University; Markus Alber, PhD - Scientific RT; John Kirkpatrick, MD, PhD - Duke University; Fang-Fang Yin, PhD - Duke University

Objectives: While single isocenter radiosurgery is becoming a common treatment for multi-focal intracranial disease, the patient specific pre-treatment QA remains a challenge due to the lack of measurement devices that can verify all individual targets simultaneously with sufficient efficiency and spatial resolution. New generation secondary dose calculation software incorporates comprehensive volumetric dose calculation with sophisticated algorithms and may enhance the radiosurgery pre-treatment QA process, however there is little published regarding experience with clinical implementation or guidelines for action criteria. Here we report our experience in the commissioning and clinical implementation of an independent dose calculation software that enables volumetric Monte Carlo (MC) dose calculation for single isocenter radiosurgery of intracranial multi-focal disease.

Methods: A 6X Flattening Filter Free photon MC beam model was commissioned within a commercial independent dose calculation software by matching calculation to various measured data including depth dose curves, central axis and off axis (5 and 9cm) profiles, central axis and off axis (2-10cm) output factors, and dosimetric leaf gap measurements. The model was verified with end to end measurements including SRS mapCHECK measurements in StereoPHAN geometry, and OSL & scintillation detector measurements in an anthropomorphic STEEV phantom (target volume = 0.1-4.1cc, distance from isocenter = 1.2-7.9cm). For 10 patient plans, passing rates for DVH based criteria were determined for the AAPM TG-219 recommended action levels of ±5% and ±7% for independent dose calculation in conditions lacking electronic equilibrium. Custom action criteria were calculated per AAPM TG-218 guidelines, and outcome was compared to the results from the pre-treatment measurement with the SRS MapCHECK in StereoPHAN geometry.

Results: The difference between the MC calculation algorithm and measurements was 0.2%±1.2% for central axis output factors and 1.4%±1.2% for off axis output factors. Gamma Index passing rate (2%, 1mm, 10% threshold) for SRS mapCHECK end-to-end measurements was 99.9.2%±2.2%. Mean dose difference for OSL/scintillator end-to-end measurements in the STEEV phantom was -2.9% ± 1.7%. Regarding the agreement between primary TPS and MC for patient cases, the difference between the TPS calculated dose and MC for the individual PTVs was -0.8% ± 1.5%, -1.6% ± 2.0%, -1.3% ± 1.7%, and -0.5% ± 1.8% for mean dose, D99%, D95%, and D1%,

respectively. This corresponded to individualized action limits of ±5.2%, ±8.3%, ±6.4%, and ±6.3%, respectively. Difference in relevant dose statistics for healthy brain (V12Gy) was negligible.

Conclusion(s): Rigorous volumetric MC independent dose calculation can enhance patient specific QA for single isocenter radiosurgery of multi-focal disease by providing comprehensive dosimetric evaluation on patient anatomy. Custom action levels for individual target D99%, D95%, and D1% were similar to the TG-219 recommended point dose action limit of ±7%, while stricter criteria could be applied for target mean dose.