Cureus

Use of Secondary Monte Carlo Dose Calculation to Select SRS Targets for Pre-Treatment Measurement

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Abstract
Published 04/02/2023

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Categories: Medical Physics, Radiation Oncology
Keywords: radiotherapy treatment planning, stereotactic radiosurgery, monte-carlo calculation

How to cite this abstract
Erickson B, Cui Y, Wang C, et al. (April 02, 2023) Use of Secondary Monte Carlo Dose Calculation to Select SRS Targets for Pre-Treatment Measurement. Cureus 15(4): a939

Abstract

Objectives:

Quality assurance (QA) for single isocenter multitarget (SIMT) stereotactic radiosurgery (SRS) cases remains cumbersome as there is no efficient way to simultaneously measure multiple targets with adequate spatial resolution. Therefore, we investigate the effectiveness of a recently commissioned secondary Monte Carlo (MC) dose calculation software to detect problematic SIMT SRS targets and to aid in selecting which targets should be verified with conventional pre-treatment measurements.

Methods:

For 21 prior SIMT SRS patients (2-20 targets per plan, 175 total, distance from isocenter = 0.9-8.4cm, volume = 0.03-34cc), the treatment plan (originally computed with AAA) was calculated with secondary MC in a series of scenarios designed to isolate sources of discrepancy: initial calculation on patient anatomy using fine statistical resolution, calculation on patient anatomy without heterogeneity corrections, and calculation on the SRS MapCHECK in StereoPHAN geometry with the target of interest centered on the detector plane. Dose differences were calculated for target mean dose, D99%, D95%, and D1%. Plans with metrics exceeding a 5% difference for target mean dose moved on to the next scenario. Plans with targets still failing on StereoPHAN geometry were measured with MapCHECK to determine agreement between the calculated and measured dose distributions. Dose differences per target were evaluated in regards to distance from isocenter, target volume, and MU-weighted modulation complexity score (MUMCS). In addition, two SIMT SRS cases were optimized on an anthropomorphic STEEV phantom using the same geometry but with different levels of modulation – one had lower modulation (MUMCS = 0.0399) and good agreement with MC while the other was over-modulated (MUMCS = 0.0118) to induce a disagreement with MC. Both were measured with MapCHECK in StereoPHAN in a true composite fashion.

Results:

For targets with >5% discrepancy between AAA and MC on StereoPHAN geometry (n=5), MapCHECK measurements had gamma pass rates (GPR) of 70.3±19.8% and 99.0±1.5% (2%/1mm with a 10% dose threshold) for AAA and MC, respectively (p=0.03). In contrast, AAA GPR were much higher (99.5%±0.9%) for a cohort with < 5% discrepancy between AAA and MC. For the plans optimized on STEEV, mean dose difference for the target furthest from the isocenter was 3.5% and 10.6% for the low and high modulation plans, respectively. These calculated dose differences correlated well with SRS MapCHECK GPR (2%/1mm with 10% threshold): for AAA this was 98.9% and 73.5% for low and high modulation, respectively; for MC this was 99.4%% and 99.5%, respectively. Target distance from isocenter and plan MUMCS (MUMCS range = 0.0085-0.0905) both impacted agreement with MC (additional disagreement of 0.94% per 2cm (p< 0.001) and 0.36% per 0.01 MUMCS (p< 0.001), respectively).

Conclusion(s):

Treatment plans with larger per-target discrepancies in the secondary MC dose calculation also showed larger discrepancies in pre-treatment patient specific QA measurement. Secondary MC can serve as an effective tool at identifying problematic plans prior to conventional pre-treatment measurements and can aid in selecting which targets should be verified with pre-treatment measurement.