AbstractID: 6516 Title: Investigation of fast Monte Carlo dose calculation for CyberKnife SRS/SRT treatment planning

Purpose: Advanced stereotactic radiosurgery (SRS) and stereotactic radiotherapy (SRT) treatments require accurate dose calculation for treatment planning especially for treatment sites involving heterogeneous patient anatomy. In this work, we have implemented a fast Monte Carlo dose calculation algorithm for SRS/SRT treatment planning with the CyberKnife® system.

Methods and Materials: Our system employs a superposition Monte Carlo algorithm. Photon mean free paths and interaction types for different materials and energies as well as the tracks of secondary electrons are pre-simulated using the EGS4 code system. Photon interaction forcing and splitting are applied to the source photons in a patient calculation and the pre-simulated tracks are repeated with proper corrections based on the tissue density and electron stopping powers. Electron energy is deposited along the tracks and accumulated in every voxel of the simulation geometry. Scattered and bremsstrahlung photons are transported, after applying the Russian Roulette technique, in the same way as the primary photons. Dose calculations are compared with full Monte Carlo simulations and the CyberKnife treatment planning system (TPS) for lung and head & neck treatments.

Results: Comparisons with full Monte Carlo simulations show excellent agreement (within 0.5%). Significant differences in the target dose are found between Monte Carlo simulations and the CyberKnife TPS for SRS lung treatment. The calculation time using our superposition Monte Carlo algorithm is reduced up to 62 times (46 times on average for 10 typical clinical cases) compared to full Monte Carlo simulations.

Conclusions: SRS/SRT dose distributions calculated by simple dose algorithms may be significantly overestimated for small lung target volumes, which can be improved by accurate Monte Carlo dose calculations. Properly implemented fast Monte Carlo algorithms can improve dosimetric accuracy with little or no compromise to computational efficiency.