AbstractID: 2555 Title: Proton dose calculation using Monte-Carlo-validated pencil beam database for KonRad treatment planning system

Purpose: To improve quality and reliability of dose calculation based on pencil beam model, in treatment planning for intensity-modulated proton therapy (IMPT).

Method and Materials: Inverse treatment planning system KonRad (developed at DKFZ Heidelberg, commercially distributed by Siemens) employs pencil beam algorithm for dose calculation. Dose distributions for proton energies of 60 through 250 MeV, and various widths of the beam were precalculated using a Monte Carlo code, based on GEANT4. The results, which included description of depth dose profiles and beam broadening in tissue due to multiple Coulomb scattering, were stored in the pencil beam database. The updated database was used to optimize IMPT treatment plans. Dose calculation, assuming delivery of optimized beam intensity patterns by continuous magnetic scanning, was repeated with Monte Carlo, and the results were then compared to those obtained with KonRad pencil-beam-based calculation.

Results: Monte Carlo calculation was in good agreement with a set of proton depth dose measurements taken in a water phantom. With the nuclear interactions “turned off”, Monte Carlo description of multiple Coulomb scattering agreed well with the theoretical model. Nuclear interactions contributed substantially to broadening of the dose distribution for higher-energy (over 150 MeV) proton beams, mainly at relatively shallow depths. Fitting both nuclear and non-nuclear contributions to a single Gaussian, for the database, produced a negligible systematic error in KonRad dose calculation at shallow depths (less than 0.3\% of the peak dose). For sample plans, Monte Carlo and KonRad dose distributions (point doses) agreed to within 5 percent of the target prescription, except in the lung (non-cancerous) tissue, where disagreement of up to 15% was observed.

Conclusion: The use of Monte Carlo data in parametrization of pencil beam kernels improved the precision of proton dose calculation without increasing the calculation time.

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