Purpose: We have developed an accurate dose calculation model based on a simplified Monte Carlo (SMC) method adapted to a beam-wobbling delivery system at National Cancer Center Hospital East (NCCHE). We used an initial beam model specific to the beam-wobbling system to reproduce accurately different dose distributions in two lateral directions (x- and y-directions) perpendicular to each other.

Methods: The SMC calculates a dose distribution by tracking individual protons. The SMC starts tracking protons at an entrance of a range compensator. Protons are generated in an initial phase space adapted to the wobbler system. Since two wobbling magnets are located at separate places with different distances from the iso-center, different dose distributions are formed in x- and y-directions. We derived an initial phase space distribution for the beam-wobbling system using an analytical method. We used the SMC method with the initial beam model to calculate dose distributions accurately. To verify accuracy of the calculation method, we measured the dose distribution in a homogeneous phantom formed by 235 MeV protons passing through a L-shaped range compensator. We used a 2D-array of parallel-plate ionization chambers (2D Array seven29®) to measure dose distributions with a sampling period of 5 mm.

Results: The measured dose distribution in the x-direction was different from that in the y-direction. Our calculation model reproduces the measurement results well in both lateral directions. In addition, the calculation reproduced the dose increments in edge regions contributed by edge-scattered protons in collimator. It indicates the advantage of the SMC.

Conclusions: A dose calculation model has been developed based on the simplified Monte Carlo method applied to a beam-wobbling system. By adapting the initial beam model to the wobbling system, the SMC method is found to reproduce observed different dose distributions in x- and y-directions well.