Photon beam modeling and verification of collapsed cone convolution algorithm for dose calculation in a radiation treatment planning system

- **Purpose**

Most commercialized radiation treatment planning systems (TPS) have adopted dose calculation algorithm to simulate the same dose distribution to the delivered dose. The TPS used specific beam models, and it based on measured dosimetric data in general. The verifications of the beam model and dose calculation algorithm were performed by comparing calculated dose distributions to the measured data. CorePLAN™ (Seoul C&J, Korea) is one of the TPS, and it adopted a specific beam model and collapsed cone convolution (CCC) dose calculation algorithm. **We evaluated its beam models for various beam setup conditions and validated the clinical acceptance of implemented CCC algorithm in the TPS.**

- **Materials and method**

1) **generation of beam models**

We modeled various photon beams for various setup conditions in a radiation treatment planning system. Each beam model was optimized by spectrum modeling from measured PDD data, dose profile modeling from a measured profile at a specific depth (10 cm) data. Using the modeling process, it was determined such as transmission ratio, horn factor and beam softening factor. Dose calculation was performed using conventional CCC algorithm. The beam models were generated at various set-up conditions such as open beam or wedged beam, 6 MV or 15 MV beam and field sizes from 4 × 4 cm² to 40 × 40 cm².

2) **Evaluation of the beam models**

All measured data were acquired from a Clinac 21EX (Varian Medical System, Palo Alto, CA, USA) linear accelerator. PDD and beam profile data were measured using a three-dimensional water phantom (Blue Phantom, ver. 7.3, Wellhofer, IBA, Germany). PDD were acquired by placing an ion chamber (CC13, Wellhofer, IBA, Germany) in the center of the beam irradiation. Then, measured depths were Dmax, 5 cm, 10 cm, 20 cm and 30 cm. The condition of beam delivery were set up that SSD is 100 cm, depth is 10 cm and dose is 100 cGy when delivery energy of photon is 6 MV and 15 MV at the water Phantom. To dose calculation, we set up dose calculation grid in 5 mm and export from calculation data to ASCII file to overlap in measured data and calculation data by using the MATLAB 7.1. After optimizing the models, all calculated PDD and dose profiles at various depths from generated beam models were compared to the measured data.

- **Results**

Calculated PDD at 10 cm depth with various field sizes are show at Figure 1. The results of PDD at all situations showed well agreement with measured data under the 10 × 10 cm² field size. For wedged cases at Figure 3, however, under the 5 cm depths, some inconsistency at penumbra region were appeared. Some calculated results by our implemented algorithm were well agreed with measured dose at small field size. (<20 x 20 cm²) In PDD, the Dmax depth of small field was reduced. But, for over 4 × 4 cm², the beam profile and PDD showed good agreement between measured and calculated data.

- **Conclusions**

In this study, we presented practical method to implement CCC algorithm in the TPS. Calculated results by our implemented algorithm was well satisfied with measured dose at small field size (<20 x 20 cm²).
Figure 1 Comparison of PDD between calculated CCC algorithm, and measured data for field sizes (4 x 4, 6 x 6, 10 x 10, 20 x 20, 30 x 30, 40 x 40 cm^2), left is 6 MV photon beam, right is 15 MV photon beam (measured: a solid line, calculated: a dotted line).

Figure 2 Comparison of open beam dose profile between calculated CCC algorithm, and measured data for field sizes (4 x 4, 6 x 6, 10 x 10, 20 x 20, 30 x 30, 40 x 40 cm^2), left is 6 MV photon beam, right is 15 MV photon beam (measured: a solid line, calculated: a dotted line).

Figure 3 Comparison of wedged beam dose profile between calculated CCC algorithm, and measured data for field sizes (4 x 4, 10 x 10, 20 x 20 cm^2), left is 6 MV photon beam, right is 15 MV photon beam (measured: a solid line, calculated: a dotted line).

Reference