A patient-specific QA procedure for moving target irradiation in scanned ion therapy

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Motivation

Three-dimensional (3D) pencil-beam scanning technique has been utilized since 2011 at the Heavy Ion Medical Accelerator in Chiba (HIMAC) [2]. Beam delivery system and treatment planning software (TPS) require dosimetric patient-specific QA to check each individual plan. Because any change in the scanned beams will result in a significant impact on the irradiation dose. Therefore, we perform the patient-specific QA for every new treatment planning before therapeutic irradiation [2]. As the existing patient-specific QA is performed only in static field to ensure the validity of both the delivered dose and the gating system, a patient-specific QA for moving target irradiation requires an additional procedure. Additional QA procedures

-- Condition of rescanning and gating system
-- Dosimetric verification with respiratory motion

Results & Discussions

Patient-specific QA in static field

In the conventional patient-specific QA, which we called static QA, the measured dose distributions agreed well with those calculated by the treatment planning system, and the QA criteria were satisfied in all measurements.

Accepted criterion

- Gamma index (3 mm-3%)
- Check--fast scanning system

Patient-specific QA procedure

The purpose of the conventional patient-specific QA is to compare the dose distribution calculated by TPS and the measured dose distribution in static field. In the additional QA for moving target irradiation, by comparing static and moving measurements, we confirm that there is no difference between them.

Measurement setup in an additional QA

In the additional QA for moving target irradiation, we place a 2D ionization chamber (Octavious Detector 729 XDR, PTW Freiburg, Germany) on the PMMA plate fitted with respect to the beam axis. The PMMA plate is set on the stage of the moving phantom (model 008PL, CIRS). The moving phantom can be moved in the transverse direction according to the patient data.

In all experiments were performed in the treatment facility at NIRS-HIMAC, equipped with all the instruments indispensable for 3D scanning irradiation, including a scanning magnet, range shifter, ridge filter and beam monitors. For depth scanning, the hybrid depth scanning method was employed, in which 11 beam energies ranging from 410 to 430 MeV/u were used in conjunction with the range shifter.

Conclusions

We performed the additional patient-specific QA for moving target irradiation with a scanned ion beam. We confirmed that this new technique was a beneficial QA procedure for moving target irradiation.

We started the treatment of a moving target by scanning irradiation to the first patient as a clinical study on March 4, 2015. The percentages of passed gamma are compared for fourteen irradiations as shown in figure 4. We confirmed that almost all data reached more than 95% of the passed gamma regardless of the amount of residual motion.