Cyberknife MLC Patient Specific Quality Assurance Using Mapcheck Diode Array

Tatsiana Reynolds, PhD, Mustafa Ozer, MS

Objectives: The implementation of multileaf collimator (MLC) into CyberKnife (CK) robotic radiosurgery system raises the necessity for CK patient specific quality assurance (QA) procedures. Different dosimeters, such as gafchromic EBT3 film, cylindrical diode array and planar ion chamber, were examined for their use of dose verification of CK plans. The feasibility of using MapCheck planar dose array system for a patient specific QA device for intensity-modulated radiation therapy (IMRT) CK plan was presented in this study.

Methods: Dose verification of 28 CK IMRT plans using MLC (10 intracranial and 28 extracranial lesions) were performed with MapCheck (Sun Nuclear 1175) detector (specifications: 445 solid state detectors, center array spacing: 7.07 mm, active detector area: 0.8 mm x 0.8 mm, total buildup to detector junction: 2.0 ± 0.1 g/cm2). Treatment volumes ranged from 3 cc to 334 cc (median 27.05 cc). 10 intracranial plans included 3 single lesion and 7 multiple lesions (2-15 lesions) plans. The treatment prescription doses ranged from 2000cGy to 6000 cGy in 1 to 5 Fx. Four fiducial markers were placed on MapCheck surface according to Accuray recommendations to enable image-based setup. Patient specific QA plan was created by overlaying the deliverable plan on a MapCheck template plan in Precision (V2.0.0.1) treatment planning system. The central axis of the device was aligned with planning tumor volume center. All beams were rearranged to be in the nominal position. The final calculations were performed with Ray Tracing calculation algorithm, high resolution and symmetrically opened grid from the central axis of diode plane. The coronal planar doses were imported to SNC patient software (V6.6.0.32313) as DICOM RTDOSE and compared to measured file. Dose comparison between measured and calculated planar doses was analyzed at 1%/1mm, 2%/2mm and 3%/3mm dose difference/distance and 10% dose threshold. The dose verification of patient plans was performed on CK M6 unit. The dose calibration was performed with CK system daily. No additional buildup was utilized for either dose calibration or delivery of QA plan to MapCheck. The daily dose verification plan was previously established in Precision with the following dose calibration conditions: MLC field size 10 x 10 cm2, source to detector distance 80 cm. After absolute dose calibration of the device, the QA plan was delivered on MapCheck using fiducial tracking.

Results: Gamma comparison of measured and calculated planar doses, based on 3%3mm, 2%/2mm and 1%/1mm, 10% dose threshold showed good agreement, with average passing rates of 100%, 99.4% and 89.2%, respectively. At 2%/2mm, 23 plans had an average passing score of 100%, and for the other 5 plans it was 96.9%. Remarkably, 4 of those 5 plans corresponded to multiple metastasis (multimets) plans. This is explained by sharp dose falloff, accumulation of the doses from multiple lesions and dose averaging by MapCheck due to device low resolution.

Conclusions: The feasibility of using MapCheck as a patient specific QA device for CK plans was demonstrated. 2%/2mm (10% threshold) criteria is recommended for MapCheck. A verification of dose delivery of multimet plans should be conducted to truly recommend the device for the patient specific multimet QAs of CK plans. A detector array with sub mm resolution is ideal for running IMRT QA plans for multimet-brain CK MLC plans, however there are no vendor arrays available on the market.