Implementation of Quality Assurance Program for CyberKnife Treatment Planning System

Tatsiana A. Reynolds, Mustafa Ozer

Minnesota Oncology, Radiation Oncology, Saint Paul, Minnesota, United States

Objective(s): Treatment planning system (TPS) is an integral part of modern radiation therapy (RT). Errors in the commissioning of TPS could lead to devastating effect on many patients. In fact, according to ICRP 86 report nearly one-third of the serious incidents in RT involve TPS. Therefore, it is essential to perform proper commissioning and quality assurance (QA) of the TPS. The major standards for TPS commissioning and QA over the last two decades have been AAPM TG 53 and MPPG 5.a. The tests recommended by those documents are only relevant to gantry-based Linacs dedicated TPSs. The standard tests for robotic arm CK dedicated TPS commissioning and QA are still missing. In this study, the necessary tests for implementing a QA program for CK dedicated TPS was established and performed in accordance with MPPG 5.a recommendations.

Methods: The implementation of the QA program for CK TPS was performed in our institution during the upgrade from TPS Precision (V1.1.1.1) (TPS1) to Precision (V2.0.0.1) (TPS2). Checklists were used to perform all nondosimetric tests.

The dosimetric tests were developed in accordance with MPPG 5.a and were performed to compare the values of the doses generated by TPS1 and TPS2. Single beam calculation QA tool was used to create all tests. The tests were created for the fixed-cone (FC), IRIS variable-aperture and multi-leaf (MLC) collimators.

Basic photon beams for FC and Iris included circular shapes fields (7.5 mm, 30 mm and 60 mm). For MLC, those tests included small and large MLC square fields (25x25 mm2, 100x100 mm2) and rectangular fields (25x100 mm2, 100x25mm2, 115x100 mm2) with extensive blocking. MLC special field blocking included concave, convex, corner block and spine block. Oblique incidence tests were created with a 30-degree angle.

Heterogeneity correction validation was performed for Ray-Trace and Monte-Carlo algorithms. The recommended minimum validation of the heterogeneity calculations included the confirmation of the CT-density table and TPS calculations within low-density tissue, near the interface of heterogeneous media and beyond lung/bone heterogeneities. Water phantom with a slab of lung/bone density tissue was used for heterogeneous calculations.

For IMRT validation, small MLC shape fields (25x25 mm2, TG 119 and 4 clinical cases) were calculated and compared for both TPSs.

All plans were calculated with high resolution (Monte-Carlo: 1% uncertainty). Axial planar doses were imported to RIT113 (V6.3) software as DICOM RT Import files. Beam measurement tools, depth profile and cross profile, were used to compare PDDs and profiles at Dmax for all listed tests, generated by TPS1 and TPS2. To ensure that the exported

PDDs and orthogonal profiles we re analyzed the same way, the dose calculation box was not modified between TPS1 and TPS2 calculations.

Results: PDDs and cross profiles at Dmax, generated by TPS1 and TPS2, were in an excellent agreement: 0% different was shown for all collimator shape basic photon beams. The maximum discrepancy was shown for Monte-Carlo heterogeneity calculations and occurred near the interface of heterogeneous media and water. The maximum deviation was 11% for lung and 9% for bone heterogeneities.

Conclusion(s): Implementation of MPPG 5.a tests into CK TPS was successful. Created set of tests will be used for subsequent TPS upgrades, as well as routine TPS QA at our institution. This work could serve as a seminal benchmark for TPS commissioning and QA of CyberKnife TPS.