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Accelerated and Standardized Commissioning of the CyberKnife S7™ Using the CyberComm™ Hybrid Golden Beam Data Model

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Abstract

Objectives: Commissioning of treatment planning systems for linear accelerators (linacs) is critical to ensure dosimetric accuracy and patient safety [1, 2]. The CyberComm™ option combines a beam tuning procedure with a hybrid Golden Beam Data (GBD) model, to accelerate and standardize the commissioning process for the CyberKnife™ (Accuray Inc, USA) system while maintaining high precision and accuracy levels. This study reports on the CyberComm – assisted commissioning of a CyberKnife S7™ system and evaluates the attained efficiency in a clinical setting.

Methods: Percentage-depth-dose (PDD) curves and cross/inline off-axis profiles (OAR) were measured on the installed CyberKnife linac to assess their matching with the reference beam model. Measurements were performed using a PTW (PTW Freiburg GmbH, Germany) 31021 Semiflex 3D ion chamber in axial setup within a PTW-MP3 motorized water phantom. Linac tuning was performed for the 60 mm fixed collimator (Cone-60) and the primary beam (open beam, i.e., without collimator housing). Beam tuning involved adjusting linac parameters (i.e., modulator PFN-HVPS, E-Gun driver cathode voltage and grid drive voltage, and the current of the two sets of beam steering coils) and was guided by gamma analysis using 1 mm/1% local and 1 mm/0.7% global gamma criteria for the Cone-60 PDD (0–300 mm depth) and Cone-60 and primary beam OAR profiles at 50 mm depth, respectively, requiring > 95% gamma pass rates. Full-beam commissioning followed using the PTW-60019 microdiamond detector. Comparison of commissioned data to the GBD model performed under 1 mm/1.5% local gamma criteria for tissue-to-phantom-ratio (TPR) measurements, while DTA and global dose difference criteria of 0.3–1 mm and 0.5–1.5%, respectively, were also employed depending on the field size and measurement depth.

Results: Using the vendor-provided linac subsystem test summary settings (cathode voltage = 12.03 kV, grid drive voltage = 164 V, PFN-HVPS = 14.91 kV, steering coil currents: X1/Y1 = 0.03/-0.29 A, X2/Y2 = 0.14/-0.42 A), initial gamma passing rates were 61% for Cone-60 PDD and 100% for crossline/inline OAR profiles. After tuning (PFN-HVPS = 14.51 kV, X1 = 0 A), passing rates improved to > 98% for both the primary beam and Cone-60 data. TPR, OAR and output factor (OF) measurements were found in close agreement with corresponding GBD (gamma passing rates > 98%), except for the OFs of field sizes < 10 mm, where deviations up to 5% were observed. Beam data commissioning for all available collimator types of the CyberKnife S7 system (Fixed, Iris™, and InCise™ MLC) was completed within 10 days.

Conclusion(s): The CyberComm – assisted commissioning of the CyberKnife system enabled fast and accurate beam model generation with excellent agreement to the GBD model. Comprehensive beam data acquisition was achieved within 10 days, comprising substantial time reduction compared to traditional commissioning procedures. Overall, CyberComm provides a reliable and efficient framework to standardize CyberKnife beam commissioning.

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