Effect of Enhanced Multileaf Collimator Leaf Modeling on Accuracy of Dose Calculation for Single Isocenter Multiple Target VMAT Radiosurgery

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Objectives: To evaluate dose calculation for Enhanced Leaf Modeling (ELM) implemented in the Eclipse v.18 treatment planning system (Varian Medical Systems, Palo Alto, CA). In contrast to previous versions of the TPS that rely on user-defined dosimetric leaf gap (DLG) and transmission parameters, ELM explicitly models the physical characteristics of the multileaf collimator (MLC), including rounded leaf ends and drive screw cutouts. Previously, we observed a dependence of calculation accuracy on target distance from isocenter. This study investigates whether ELM's physics-based approach improves calculation accuracy, particularly for off-axis targets in single-isocenter multi-target treatments. We hypothesized that ELM would improve calculation accuracy.

Methods: We selected 60 clinical volumetric modulated arc therapy (VMAT) radiosurgery plans treated using a 10 MV flattening filter free beam and an MLC having 2.5 mm central leaf width (HDMLC, Varian Medical Systems, Palo Alto, CA). The cohort included 30 single-target and 30 multiple-target plans treated using a single isocenter. For each plan, measurements were done using a 0.8 mm3 plastic scintillator detector (W2, Standard Imaging, Madison, WI) placed in the center of the smallest and largest targets (90 measurements). Measured doses were compared with calculations using AcurosXB v.18 with ELM (AXB_ELM) and with AcurosXB v.16 having DLG and transmission parameters manually optimized for VMAT SRS (AXB_DLG).

Results: The median target volume was 0.35 cc (range 0.007 to 46.8). The median target offset from isocenter was 3.0 cm (range 0.0 to 7.4). The mean dose difference between AXB_ELM and AXB_DLG was 0.2% (range -3.8% to 2.2%). The mean difference between calculation and measurement was -0.9% (range -7.5% to 7.3%) and -0.7% (range -7.5% to 7.2%) for AXB_ELM and AXB_DLG, respectively. Distance from isocenter was predictive of difference from measurement for both models. A linear fit to the difference between calculation and measurement yielded 0.5%/cm (R2 = 0.28) and 0.7%/cm (R2 = 0.34) for AXB_ELM and AXB_DLG, respectively. We used k-means clustering to group the dose differences into two clusters by distance from isocenter. Both AXB_ELM and AXB_DLG were partitioned into the same groups separated at 2.6 cm from isocenter. The mean difference for targets less than 2.6 cm from isocenter was -2.2% (range -7.5% to 2.0%) for AXB_ELM and -2.5% (range -7.5% to 3.4%) for AXB_DLG, whereas for targets further than 2.6 cm from isocenter the mean difference was 0.2% (range -3.5% to 7.3%) for AXB_ELM and 0.8% (range -3.5% to 7.2%) for AXB_DLG.

Conclusion(s): The accuracy of AcurosXB with enhanced leaf modeling is comparable to that using user adjustable DLG and leaf transmission. The advantage of ELM is efficient configuration that is not user dependent. A change in accuracy with distance from isocenter was observed for both models, suggesting that the cause of this observation is not related to modeling of the MLC but is related to some other aspect of beam modeling.