DEVELOPMENT AND VALIDATION OF A MONTE CARLO DOSIMETRIC QUALITY ASSURANCE SYSTEM FOR DYNAMIC INTENSITY-MODULATED RADIOTHERAPY

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Purpose: Intensity-modulated radiotherapy (IMRT) is one of the advanced radiotherapy techniques which can deliver high doses to tumor and spare surrounding normal tissues with non-uniform intensity distributions generated by a computer-aided optimization process. The commercial treatment planning systems cannot predict the accurate dose in the intensity modulated fields mainly due to the electronic disequilibrium and the dosimetric effects of multileaf collimator (MLC). Monte Carlo (MC) is the only option to resolve that issue and enables the accurate dose computation. The main purpose of this study is to develop an MC dose calculation system incorporating the detailed geometry of the MLC for routine dosimetric quality assurance (QA) of IMRT.

Materials/Methods: The Varian Clinac 2300C/D linear accelerator equipped with the 80-leaf Mark II MLC was modeled using the EGS4 MC code for 6 and 15 MV photon beams. The MLC was modeled fully incorporating its specific design. The MC treatment head model was validated with the measurement data sets of the depth doses and the off-axis lateral dose profiles in the water phantom. The MLC model was validated with the film measurements for four types of its dosimetric effects: inter-leaf leakage, intra-leaf transmission, tongue-and-groove underdosage effect, and rounded leaf tip effect, which are significantly affected by the MLC geometry. A clinical leaf sequence file for a prostate cancer patient was employed for the validation when incorporating the dynamic leaf movements.

Results: In the treatment head model for 6 and 15 MV photon beams, the MC calculated results agreed well with the measurements to within 1% for both of depth doses and dose profiles. All of the MLC dosimetric effects were well reproduced by MC. The MC calculated off-axis dose profiles for inter-leaf leakage, intra-leaf transmission, tongue-and-groove effect, and rounded leaf tip transmission were found to

agree with film measurements to within 3%. Also, in the dynamic case, the calculated intensity pattern agreed well with the measurement. The discrepancies between them were overall within 4%.

Conclusions: An MC dosimetric QA system for dynamic IMRT was successfully developed and its accuracy was validated. Since this system fully takes the MLC dosimetric effects into account, it can be a powerful tool to provide the benchmark data for verification of the results from IMRT commercial treatment planning systems.