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Source Head Fluence Modulation in Cobalt-60 Teletherapy: A dosimetric and Monte Carlo study

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Background and Purpose: Innovations in external beam radiotherapy have been limited to linear accelerators, yet radiotherapy began with cobalt-60 teletherapy. One such technology is called intensity modulated radiotherapy (IMRT), which can be executed with cobalt-60 teletherapy units to yield dosimetric characteristics that are comparable with linear accelerator beams. The lower energy and weaker penetration may be negligible in the delivery of efficient IMRT in cobalt-60 teletherapy especially for head and neck cancers with superficial extent. The aim of this study was to investigate the implementation of step and shoot technology in cobalt-60 teletherapy.

Materials and Methods: A clinical MDS Nordion Equinox 80 unit was used at dose rates of 67.7 ± 7.4 cGy/min and 61.4 ± 3.1 cGy/min. Three intensity maps were prescribed with Oncentra 4.3, and they were verified with GafChromic EBT2 film measurements in a PTW universal IMRT verification phantom. Two other measurements were made with GafChromic RTQA2-1010 film whilst a physical compensator was constructed and placed in the accessory holder. A 0.125 cc PTW 31010 Semiflex thimble chamber was used for dose rate constancy checks, and a calibrated Lufft OPUS 20 was used to monitor temperature and pressure. Images of post-irradiation films were acquired prior to net optical density readouts and normalised lateral beam profile plots. Two-dimensional gamma index evaluations of the results were made against Monte Carlo simulations of three source diameters.

Results and Discussion: Film calibration curves showed that GafChromic RTQA2-10101 film had a low dose response than GafChromic EBT2 film. Normalised lateral beam profiles generated from film measurements and Monte Carlo simulations output data revealed that step and shoot technology can be executed in cobalt-60 teletherapy by symmetric and asymmetric segmented secondary collimator jaw motion or by using a three-dimensional physical compensator. Gamma passing rates were highest between physical measurements and Monte Carlo simulations of a 1.5 cm diameter source when using 3 mm, 3 % and 5 mm, 5 % criteria. Furthermore, radiochromic film can be a viable tool for dose verification and quality assurance measurements in resultant beam fluence maps.

Conclusions and Future Recommendations: Sharply defined beam intensities can be achieved in cobalt-60 teletherapy by a shift to small source diameters, as revealed by the results of Monte Carlo simulations for the smallest source diameter. Effort is needed to extend this study to the use of multileaf collimation for more complex beam intensity.

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