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An Optimized Design of Beam Modifiers for Total Skin Electron Irradiations

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Total skin electron irradiation (TSEI) with a single field requires large electron beams, while maintaining a certain level of flucence rate and dose uniformity, dmax at the skin surface, and low bremsstrahlung contamination. To satisfy these requirements, we used Monte Carlo (MC) techniques to design beam modifiers for a clinical linear accelerator. By matching MC simulations to the standard dose measurements of the accelerator, the parameters of primary electrons were determined to be mono-energetic at 6.72 MeV, parallel, and circular beams having a Gaussian radial distribution with FWHM = 0.13 cm. They were then used to simulate the accelerator together with one of eight sets of beam modifiers. The objective function to rank the simulated results of the beam modifiers was defined as a product of two indices reflecting the fluence rate and the dose uniformity. An energy degrader of a 0.6 cm-thick PMMA plate, blacking a jaw-shaped field (40 cm × 40 cm) at 100 cm SSD, showed the best performance. A flattening filter, consisting of a 12 cm × 12 cm aluminum plate of 0.6 cm-thickness and placed just behind the energy degrader was considered 3% up±optimal. Such optimized combination produced a beam that was flat within to 60 cm off-axis distance, dropped by not more than 6% at a distance of 90 cm, and had a fluence rate to complete the treatment within 7 min and an x-ray contamination of < 3%. For stationary beams, MC-computed dmax, Rp, and R50 agreed with measurements within 0.5 mm. The MC-predicted surface dose of the rotating phantom was 41% of the dose rate at dmax of the stationary phantom, whereas the calculations based on a semi-empirical formula in the literature yielded a drop to 42%. The MC simulations provided the guideline of beam modifier design for TSEI and estimated the dosimetric performance for stationary and rotational irradiations.

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