Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **2990** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Monte Carlo Simulation of FFF Photon Beam in Radiotherapy

Tuesday 7 June 2022 14:15 (15 minutes)

Objective: When 3-dimensional conformal radiotherapy is eventually replaced by intensity modulated radiotherapy, the flattening filter (FF) can be removed from the medical linear accelerator (Linac). Although the flattening-filter-free (FFF) photon beam has some advantages such as higher beam output and less head scatter in dose delivery, there is a dosimetric concern over the low-energy photons in the FFF beam. This study investigated dosimetric changes when FF is removed from the Linac in doses of skin, bone and mucosa, beam angle and skin dose enhancement, when patient used topical cream during radiotherapy.

Methods: Monte Carlo simulations using the EGSnrc-based code were carried out using various water and heterogeneous phantoms containing bone, air and water. The mean doses on the phantom surface, and at the bone and mucosa were determined with various beam energies (6-10 MV), beam angles (0-90 degree) and presence of FF in the Linac. In addition, the photon energy distribution on the phantom surface and mean photon energies of the bone and mucosa were determined.

Results: For the water phantom, the output of the FFF photon beam was found more than two times of the FF beam. The dose at the phantom surface for the FFF photon beam was higher than the FF beam, and the results varied with the beam obliquity. Moreover, lower mean bone dose was found for the FFF photon beam compared to the FF beam, and the FFF beam contained more low-energy photons than the FF beam on the phantom surface. With application of topical cream in the phantom, dependence of dose enhancement on the cream thickness was found sensitive to the beam angle.

Conclusion: It is concluded that dosimetric changes are present on the photon beam when FF was removed from the Linac. This change is mainly due to the presence of low-energy photons in the FFF beam.

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Session Classification: T3-1 Advances in Physics in Biology and Medicine Symp.: Physics in Medicine (DPMB) | Symposium sur les progrès en physique dans la biologie et la médecine: la physique en médecine (DPMB)

Track Classification: Symposia Day (Tues. June 7) / Journée de symposiums (mardi, le 7 juin): Symposia Day (DPMB) - Advances in Biological and Medical Physics Symposium