Bone heterogeneity in orthovoltage radiotherapy

Innovation/Impact: We used Monte Carlo method to show that neglecting the bone heterogeneity in some treatment sites (e.g. forehead, knee and chest wall) might result in an uncertainty of 2.5 – 3.7% in the dose prescription of orthovoltage radiotherapy.

Methods: A heterogeneous phantom (Fig. 1) containing water (thickness = 1 – 5 mm) over a bone (thickness = 1 cm) was used in Monte Carlo simulations (the EGSnrc code). A 220 kVp photon beam with field size of 5 cm diameter was used to irradiate the phantom with source-to-surface distance = 20 cm. Percentage depth dose (PDD), surface dose and photon energy spectrum at the phantom surface were calculated.

Results: Fig. 2: From PDDs, maximum dose was found to be about 210% in the bone.

Fig. 3: Surface dose is increased between 2.5 and 3.7% when the water thickness is increased in the range of 1 – 5 mm over the bone.

Fig. 4: Relative intensity of the spectral curve for water thickness = 3 mm is higher than those of 1 and 5 mm. This gives the maximum surface dose at water thickness = 3 mm (Fig. 3). The surface dose is affected by both the loss of backscatter compared to full scattering condition and bone backscatter to the phantom surface. Since both effects become weaker when the bone is located further from the phantom surface, the combination of these two effects results in a maximum surface dose at a bone depth = 3 mm.

Conclusions: An increase of surface dose of 2.5 – 3.7% was found when considering bone heterogeneity in some skin sites with a thin tissue layer over a bone in orthovoltage radiotherapy.

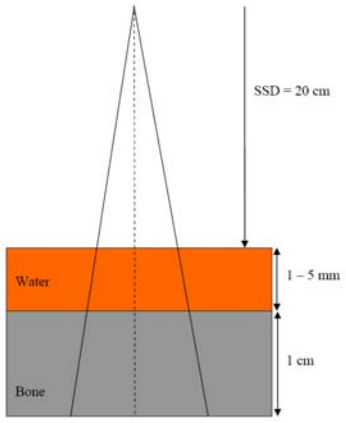

Fig. 1: Heterogeneous bone phantom.

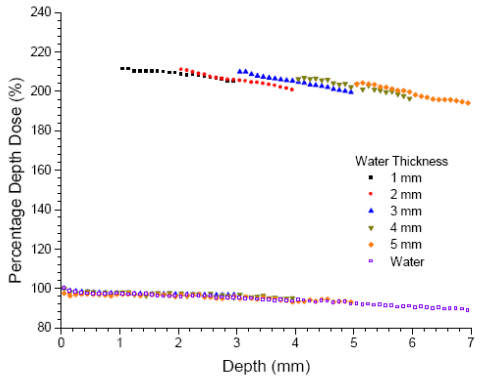

Fig. 2: PDDs of the heterogeneous phantom varying with water thickness.

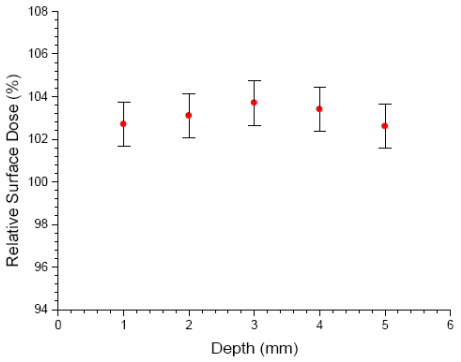

Fig. 3: Relative surface dose vs. water thickness over the bone. Surface dose normalized to a water phantom.

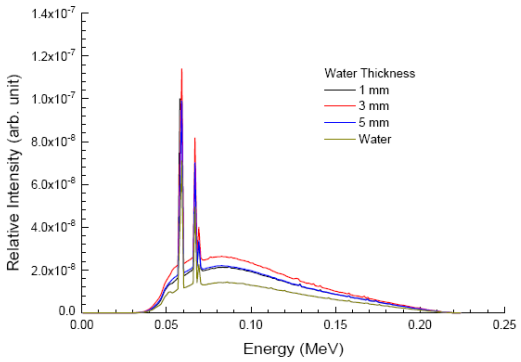

Fig. 4: Relative photon energy spectra at the phantom surface with different water thicknesses.