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Comparison of Water Equivalent Ratio of Several Dosimetric Materials in Proton Therapy Using Monte Carlo Simulations and Experimental Data

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Abstract : Range uncertainties of protons are currently a topic of interest in proton therapy. Two of the parameters that are often used to specify proton range are water equivalent thickness (WET) and water equivalent ratio (WER). Since WER values for a specific material is nearly constant at different proton energies, it is a more useful parameter to compare. In this study, WER values were calculated for different proton energies in polymethyl methacrylate (PMMA), polystyrene (PS) and aluminum (Al) using FLUKA and TRIM codes. The results were compared with analytical, experimental and simulated SEICS code data obtained from the literature. In FLUKA simulation, a cylindrical phantom, 1000 mm in height and 300 mm in diameter, filled with the studied materials was simulated. A typical mono-energetic proton pencil beam in a wide range of incident energies usually applied in proton therapy (50 MeV to 225 MeV) impinges normally on the phantom. In order to obtain the WER values for the considered materials, cylindrical detectors, 1 mm in height and 20 mm in diameter, were also simulated along the beam trajectory in the phantom. In TRIM calculations, type of projectile, energy and angle of incidence, type of target material and thickness should be defined. The mode of 'detailed calculation with full damage cascades' was selected for proton transport in the target material. The biggest difference in WER values between the codes was 3.19%, 1.9% and 0.67% for Al, PMMA and PS, respectively. In Al and PMMA, the biggest difference between each code and experimental data was 1.08%, 1.26%, 2.55%, 0.94%, 0.77% and 0.95% for SEICS, FLUKA and SRIM, respectively. FLUKA and SEICS had the greatest agreement (≤0.77% difference in PMMA and ≤1.08% difference in Al, respectively) with the available experimental data in this study. It is concluded that, FLUKA and TRIM codes have capability for Bragg curves simulation and WER values calculation in the studied materials. They can also predict Bragg peak location and range of proton beams with acceptable accuracy.

Keywords : water equivalent ratio, dosimetric materials, proton therapy, Monte Carlo simulations
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