ABSTRACT

Prostate cancer is the second most common malignancy in men worldwide, with 13,130 new cases and 4,860 deaths reported in Indonesia in 2022. Proton therapy offers high precision through the Bragg peak phenomenon, but previous studies have been limited to a small number of beam-angle configurations under homogeneous-tissue assumptions. This study validates Geant4 simulations against integral depth-dose data, designs eight optimal proton beam directions, and simulates organ-at-risk (OAR) doses for 255 beam-angle combinations in homogeneous and heterogeneous ICRP 145 MRCPs phantoms, for a total of 510 simulations. Pencil-beam spot-scanning with Spread-Out Bragg Peak (SOBP) modulation and multi-criteria optimization using the OARScore metric is applied. Validation shows Bragg-peak range deviations of 1-2 mm, within ICRU/AAPM tolerances. A five-field combination (0°-45°-135°-225°-315°) is identified as a top-stable configuration, ranking first in 6 of 9 clinical weighting scenarios. A posterior-only beam (180°) yields the highest rectal dose (4.84 Gy) and should be avoided, while tissue heterogeneity induces a 1-1.5 cm range shift. Geant4 simulations with MRCPs ICRP 145 phantoms are accurate for planning prostate proton therapy, and symmetric anterior-oblique beam arrangements are optimal for balancing target coverage and OAR protection.

Keywords: *proton therapy, prostate cancer, Geant4, MRCPs ICRP 145, beam-angle optimization.*