

Purpose:

The risk of second malignant neoplasms (SMNs) following prostate radiotherapy is a concern due to the large population of survivors and decreasing age at diagnosis. It is known that parallel-opposed beam proton therapy carries a lower risk than photon IMRT. However, a comparison of SMN risk following proton and photon arc therapies has not previously been reported. The purpose of this study was to predict the ratio of excess relative risk (RRR) of SMN incidence following proton arc therapy to that after VMAT. Additionally, we investigated the impact of margin size and the effect of risk-minimized proton beam weighting on predicted RRR.

Methods:

Physician-approved treatment plans were created for both modalities for three patients. Proton arc treatment plans were approximated with 16 equally spaced and uniformly weighted passively-scattered proton beams, and VMAT plans were created with two 6-MV arcs. Therapeutic dose was obtained with differential dose-volume histograms from the treatment planning system, and stray dose was estimated from the literature or calculated with Monte Carlo simulations. Then, various risk models from the literature were applied to the total dose to span the likely dose-risk relationship. Additional treatment plans were also investigated with varying margin size and risk-minimized proton beam weighting, and their respective RRRs calculated.

Results:

The mean RRR ranged from 0.74 to 0.99, depending on risk model, suggesting a lower predicted risk of SMN following proton arc therapy. The additional treatment plans revealed that the RRR remained approximately constant with varying margin size, and that the predicted RRR was reduced by 12% using a risk-minimized proton arc therapy planning technique.

Conclusions:

Proton arc therapy was found to provide an advantage over VMAT in regard to predicted risk of SMN following prostate radiotherapy. This advantage was independent of margin size and was amplified with risk-optimized proton beam weighting.