

Purpose: Brachytherapy is often used in combination with external-beam-radiotherapy to deliver a tumoricidal dose, while respecting critical organ tolerances. Its biological equivalence to an external beam dose fractionation has conventionally been considered via only the prescribed dose, preventing the 3D summation of brachytherapy and external beam dose distributions. We investigate a methodology that calculates a brachytherapy dose distribution biologically equivalent to an external beam dose fractionation schedule using a commercial treatment-planning system that has only conventional brachytherapy dose calculation models.

Method and Materials: Dose distributions from high-dose-rate (HDR) brachytherapy treatments, including point-source, line-source, planar, and intracavitary gynecological implants were converted to their biological equivalents for corresponding external beam dose fractionations using the linear quadratic equation and an α/β ratio of 10. The radial-dose-function (RDF) values of an Ir-192 source were modified (BRDF) to yield these biologically-equivalent dose distributions using the conventional dose calculation formalism. Use of this formalism was demonstrated by planning an IMRT treatment of cervical cancer constrained by delivered HDR dose distributions.

Results: The BRDFs of HDR Ir-192 treatments vary as a function of external beam dose fractionations, the α/β ratio used, and implant geometry. BRDF's dependence on implant geometry is due to the nonlinearity of the linear-quadratic equation. BRDF's have non-unitary values at 1 cm from the source, depending on the equivalence of prescribed external beam and brachytherapy doses. Comparisons between the biological-equivalent dose distributions and the approximations obtained using BRDF showed excellent agreement.

Conclusion: A method is proposed to allow calculation of biologically-equivalent brachytherapy dose distribution in commercial treatment planning systems. Preliminary studies using the BRDF demonstrated its usefulness in the IMRT treatment planning when constrained by delivered brachytherapy dose distribution. The process can also be used to review brachytherapy implant dose distributions at conventional external-beam fractionation schedules.