Title: Monte Carlo design of an internally-shielded peripheral breast brachytherapy applicator

Purpose: The AccuBoost® breast brachytherapy system applies HDR ^{192}Ir irradiation under mammographic image guidance. The round- and D-type applicators have been developed and are in clinical use. However, it is possible to improve upon the resultant dose distributions through introduction of an internal shield for sparing the skin. The design of this internal shield has been optimized using Monte Carlo methods to retain tumor dose uniformity while minimizing skin dose.

Materials and Methods: Dose distributions in breast tissue from a round applicator (60 mm internal diameter) were obtained by varying the dimensions of the tungsten-alloy internal shield. Specifically, the superior diameter and inferior diameter of the shield were varied and generally took the shape of a truncated cone. Dimensions were chosen for cone foci at tissue depths, d, of 0, 2, 5, and 10mm with field edges –1, 0, and +1mm from the source dwell plane. The MCNP5 radiation transport code was used for calculating breast dose throughout a cylindrical phantom R=15cm radius and H=8cm high.

Results: Cone design 7 was determined to be the best design. This design had relatively uniform skin dose distribution and relatively good retained tumor dose. Average skin dose was about 70% of the maximum dose, which was improved by about 27%. Average skin dose was reduced by more than 44% compared to that of an applicator without a cone. The maximum reduction in skin dose was 92%, which was typically outside the applicator aperture. In the mean time, average tumor dose at 30 mm depth was only about 5% lower than that of applicator without a cone.

Conclusions: Significant improvements in critical structure dose can be obtained through introduction of an internal shield, with design optimization using Monte Carlo methods.