A Dosimetric Characterization of an Electronic Brachytherapy Source in Terms of Absorbed Dose to Water

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Miniature x-ray sources developed by Xoft Inc. are used for clinical high dose rate brachytherapy treatments. The characterization of these Xoft Axxent electronic brachytherapy sources follows a modification of the American Association of Physicists in Medicine's Task Group 43 formalism (TG-43U1). These sources were characterized in terms of air-kerma strength at the University of Wisconsin Medical Radiation Research Center. This thesis investigates the absorbed dose to water parameters as described in TG-43U1 for the Axxent sources. In particular, the dose-rate constant was determined, which is the necessary parameter to obtain absorbed dose to water from the TG-43U1 formalism.

The dose-rate constant was calculated and measured with several methods. A full model of the Axxent source was used to calculate the dose-rate constant with the Monte Carlo (MC) code PENELOPE. The dose-rate constant was measured with thermoluminescent dosimeters (TLDs) in liquid water and an Axxent-specific energy dependence correction was determined and applied to TLD data. The dose-rate constant was measured in liquid water with three air-kerma calibrated ionization chambers. Corrections to obtain dose to water were calculated by modeling each chamber with the MC code EGSnrc. The dose-rate constant was analytically determined from the measured Axxent spectrum, which was fully corrected using a backward stripping technique from Moga. Modifications were made to the analytical methods of Chen and Nath for dose-rate constant determination.

Relative parameters of TG-43U1 were determined with several methods. Azimuthal anisotropy and radial dose function were determined from TLD measurements. The radial dose function was also calculated from ionization chamber measurements and compared to TLD results. Azimuthal anisotropy, polar anisotropy and the three dimensional dose distribution of the Axxent source were measured with a specially-designed phantom.

A consensus dose-rate constant was determined from the calculations and measurements performed in this work. This value directly affects patient treatments and confirms the value currently recommended for use by the manufacturer.