Abstract

A variety of low-dose rate (LDR) radioactive sources are used for a number of different cancer treatments. The conventional LDR brachytherapy sources are azimuthally-symmetric. If a directional LDR radioactive source could be used for such procedures, it could potentially lead to an improvement in the therapeutic ratio for these treatments by selectively targeting malignant tissue. The CivaSheet is one such novel device manufactured by CivaTech Oncology Inc. The CivaSheet is a planar array consisting of discrete directional ^{103}Pd elements called CivaDots. A gold shield is present in each CivaDot and imparts directionality to the radiation output of the device. Since the source geometry and design are considerably different than conventional LDR sources, a thorough investigation was required to ascertain the dosimetric characteristics of the device prior to its clinical implementation.

The primary aim of this work was to establish a source strength framework for this directional planar source array as well as determine its dosimetric characteristics. Existing dosimetric formalisms were adapted to accommodate a directional source, and other distinguishing characteristics including the presence of gold shield x-ray fluorescence present in the source energy spectrum were addressed in this work. Primary air-kerma strength measurements were performed, and the source energy spectrum as well as anisotropy distribution were investigated. The feasibility of transferring the primary measurement to a well-type ionization chamber for clinical use was also assessed. Various Monte Carlo simulations of the source were performed. Analogous TG-43 dosimetric parameters for the CivaDot were determined using dose distribution measurements and Monte Carlo methods.

The dose distribution of a CivaSheet was investigated and the impact of a curvature of the CivaSheet on the source dose distribution was also evaluated.

Up to this point, there were no traceable standards for a directional source. This work assisted in the establishment of a primary source strength standard for the directional CivaDot source in collaboration with the National Institute of Standards and Technology (NIST). Clinical physicists are not able to perform treatment planning tasks without appropriate measurements and associated dosimetric data provided in the literature. This work sought to add knowledge to the dosimetry of directional and planar low-dose rate brachytherapy source arrays and ultimately enable clinical physicists to verify their source strength with NIST-traceable calibrations, and look up the relevant dosimetric data in the literature. The investigations performed in this work have facilitated the ongoing clinical implementation of the CivaSheet device and represent a noteworthy advancement in the science of brachytherapy physics.