Dosimetric characterization of surface applicators for use with high dose rate ^{192}Ir and electronic brachytherapy sources

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Historically, treatment of malignant surface lesions has been achieved with linear accelerator based electron beams or superficial x-ray beams. Recent developments in the field of brachytherapy now allow for the treatment of surface lesions with specialized conical applicators placed directly on the lesion. Applicators are available for use with high dose rate ^{192}Ir sources, as well as electronic brachytherapy sources. Although use of these applicators has gained in popularity, the dosimetric characteristics including depth dose and surface dose distributions have not been independently verified. Additionally, there is no recognized method of output verification for quality assurance procedures with applicators like these. Existing dosimetry protocols available from the American Association of Physicists in Medicine (AAPM) bookend the cross-over characteristics of a traditional brachytherapy source (as described by Task Group 43) being implemented as a low-energy superficial x-ray beam (as described by Task Group 61) as observed with the surface applicators of interest (Rivard, 2001)(Rivard et al., 2004; Ma et al., 2001). This thesis work aims to create a cohesive method of output verification that can be used to determine the dose at the treatment surface as part of a quality assurance/commissioning process for surface applicators used with high dose rate ^{192}Ir and electronic brachytherapy sources. Air-kerma rate measurements were completed with an Attix Free-Air Chamber, as well as several models of small-volume ionization chambers to obtain an air-kerma rate at the treatment surface for each applicator. Correction factors were calculated using MCNP5 and EGSnrc Monte Carlo codes in order to determine an applicator-specific absorbed dose to water at the treatment surface from the measured air-kerma rate. Additionally, relative dose measurements of the surface dose distributions and characteristic depth dose curves were completed in-phantom and in-water. Theoretical dose distributions and depth dose curves were generated for each applicator and agreed well with the measured values. A method of output verification was created that allows users to determine the applicator-specific dose rate in water at the treatment surface based on a measured air-kerma rate. The novel output verification methods described in this work will reduce uncertainties in dose delivery for treatments with these kinds of surface applicators, ultimately improving patient care.