Measurements of a new Xoft Axxent Source Model using an A26 Microionization Chamber

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Objective: Dosimetric characterization of electronic brachytherapy (eBt) sources has been a challenge in the field of radiation therapy due to bremsstrahlung perturbations and fluctuations in dose rate that are not present for traditional brachytherapy sources. Thus, NIST has implemented an air kerma rate standard for these sources [1,2] instead of the use of the air kerma strength standard. The implementation of this standard requires a modified dosimetry formalism [2]. Previously, implementation of this standard for the S7500 model of the Xoft Axxent electronic brachytherapy source (San Jose, CA) was done [3]. A new S7600 Axxent source model has been produced and utilizes a Galden coolant material, which has a density of 1.72 g/cc, and has an increased thickness of the anode. These changes to the source require a new air kerma rate standard to be implemented as well as measurement of the modified TG43 parameters. The previous characterization of these sources has utilized TLD-100 microcubes, as they provided high dose resolution and the most precise measurements of these miniature x-ray tubes when compared to ionization chamber or film measurements. Historically, microionization chambers with volumes suitable for these measurements have had a steep energy dependence within the range of tube potentials of these sources due to high-Z collectors, variable responses over time, and significant polarity and ionic recombination effects [4,5]. The Exradin A26 microionization chamber (Standard Imaging, Middleton, WI) has been shown not to have these issues. Thus, the focus of this work was to evaluate the use of this ionization chamber to measure some modified TG43 parameters for the S7600 source.

Methods: Air kerma rate was measured using the Attix Free Air Chamber (FAC) at the UWMRRC [6] for six S7600 Axxent sources. Charge readings were also taken in Standard Imaging HDR1000+ well chambers (Middleton, WI) with a previous NIST calibration for the S7500 sources. The FAC was used to determine source-specific calibration coefficients, as a standard has not currently been implemented for these new source models. A tentative calibration coefficient was then assigned to the well chambers from these measurements.

Measurements were then made in water with an Exradin A26 microionization chamber. An acrylic phantom (Figure 1) was used to place the active volume of the chamber at distances of 1 cm to 4 cm away from the source anode [7]. Charge readings were taken at two points separated by 180˚ for each of the distances. These charge readings were corrected for temperature, pressure, and electrometer and had a UW M50 calibration coefficient applied. The dose rate at each distance was calculated and used in Equation 1 to calculate the radial dose function as,

$$g(r) = \frac{\dot{D}(1\ \text{cm},90^{\circ})}{\dot{D}(r,90^{\circ})}\frac{G(r_0,\theta_0)}{G(r,\theta_0)} \qquad (1)$$

where r indicates the radial distance. The geometry function, G(r,θ) can be simplified to a point source approximation and acts as a correction for dose fall off. Additionally, the Dose Rate Conversion Coefficient, χ, can be calculated from these measurements as,

$$\chi = \frac{\dot{D}_{1\ \text{cm}}}{\dot{K}_{50\ \text{cm}}} \qquad (2)$$

where $\dot{D}_{1\ \text{cm}}$ is the dose rate measured at 1 cm with the A26 chamber and $\dot{K}_{50\ \text{cm}}$ is the air kerma rate at 50 cm, determined from the FAC. Additionally, these measurements were simulated using the EGSnrc user code egs_chamber following the methods of Simiele [3].

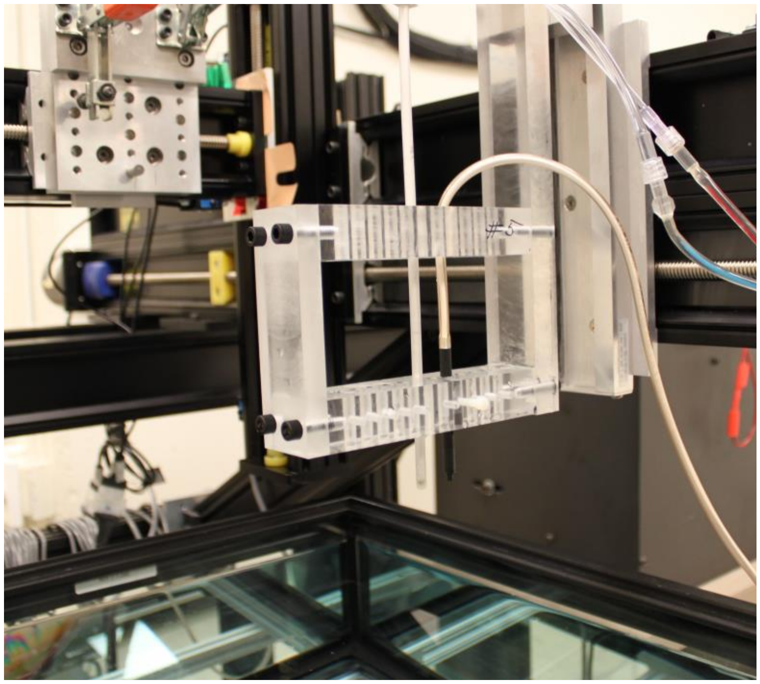

Figure 1: Acrylic phantom used to position the A26 and Axxent source [7].

Results:

The tentative calibration coefficients for the well chambers for the S7600 sources were approximately 17% lower than those for the S7500 sources. This result emphasizes the need for an air kerma rate standard for the S7600 sources.

The measured values for the radial dose function agreed within 2% of the simulated values. These results are shown in Table 1 and are plotted as a function of radial distance in Figure 2. Additionally, the DRCC, χ, measured with the A26 chamber was 9.36±0.212 $\frac{\text{cGy/hr}}{\mu\text{Gy/min}}$ and agreed within 0.9% of the simulated value of 9.44 ±0.294 $\frac{\text{cGy/hr}}{\mu\text{Gy/min}}$.

Table 1: Comparison of measured and simulated radial dose function values

Radial Distance (cm)	***A26, g(r) (%)***	***MC, g(r)***	***Ratio (A26/MC)***
1	1.000±0.002 (0.2)	1.000	1.00
2	0.645±0.002 (0.3)	0.632	1.02
3	0.475±0.003 (0.6)	0.465	1.02
4	0.361±0.005 (1.4)	0.360	1.00

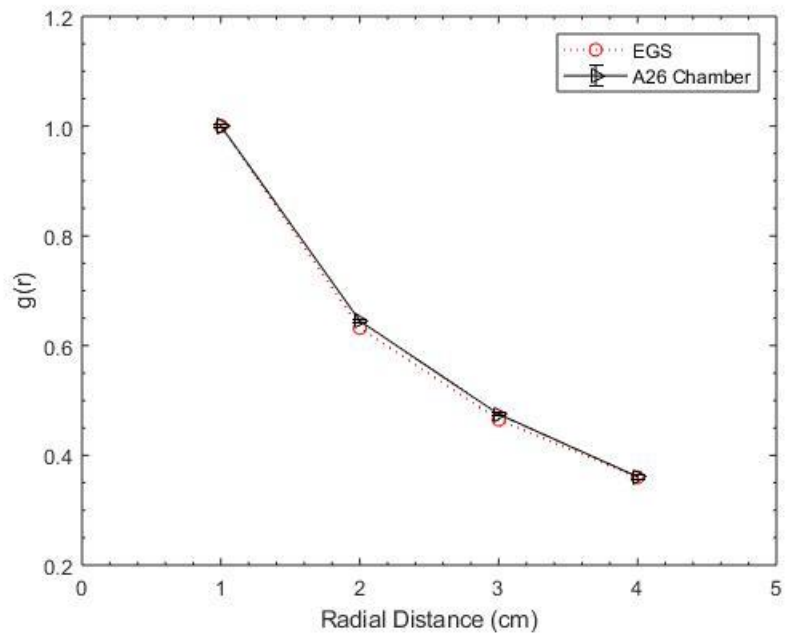

Figure 2: Simulated and measured values for the radial dose function

Conclusion and Significance: This study successfully showed the feasibility of using an A26 microionization chamber for measurement of a subset of modified TG43 parameters for the S7600 Axxent source model. The aim of future work will be to utilize NIST traceable air kerma rate values to determine the measured values following the implementation of a standard. Additionally, these results will be used to benchmark Monte Carlo models using the TOPAS user code.

Relevance to CIRMS: This work is a subset of the doctoral work pursued by the first author to dosimetrically and biologically characterize the S7600 Axxent source model. This work relates to the CIRMS mission as these values rely on a NIST traceable standard to ensure accuracy of dose calculation for patient treatments. Additionally, the work will aid in implementation of consensus values to be used by all clinical users for patient treatment. CIRMS will help the first author achieve her goal of working as a clinical medical physicist by providing the tools and resources to conduct radiation metrology research now and in the future.

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