Investigating the effect of eye size and shape on normal tissue doses

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Abstract

This study investigates the effect of eye size and eccentricity on doses to critical normal tissues by simulating treatment plans in the Plaque Simulator (v. 6.3.1) software. Present OHSU plaque brachytherapy treatment focuses on delivering radiation to the tumor measured by an ocular ultrasound plus a small margin, but assumes that the orbit has the dimensions of the default "standard eye" model in Plaque Simulator (equatorial diameter of 24 mm; eccentricity of 1.00). Patients with unusual ocular anatomy require a high resolution ocular CT to properly model their true ocular anatomy. This study quantifies how differences in equatorial diameters and eccentricity affect calculated doses to critical structures in order to query the justification of the additional CT scan for patients with unusual ocular anatomy.

Methods

Tumors of 10 mm x 10 mm x 5 mm were modeled at the 12:00:00 hour with a latitude of 45 degrees (85 Gy over 100 hours). Variations in the calculated doses to normal structures were examined to see if the changes were significant between different equatorial diameters and eccentricities.

Variation in dose due to eye size

Data for the differences in dose to normal tissues due to equatorial diameters were measured for eccentricities of 0.85, 0.90, and 1.00 for all of the standard non-notched COMS plaques.

The user is able to input custom equatorial diameters into Plaque Simulator to match the patient’s true orbital anatomy (see Figure 1). For brevity, only one data set is presented below (eccentricity = 1.00; see Figure 3).

At a glance, the most marked difference between the experimental groups is the dose to the sclera from eccentricities of 0.85 to 1.00 (294.2 and 226.6 Gy, respectively; 17% difference).

However, the opposite disc, opposite retina, eye origin, and macula all saw an increase of dose ranging between 16-18% for more eccentric (E=0.85) eye models than the standard model (E=1.00). The exception is the dose to the lens, which decreased by 3.5% (from 78.99 to 76.31 Gy) between eccentricities of 0.85 and 1.00, respectively.

Conclusions

The calculated dose to normal structures showed a marked dependence on eye geometry. This is exemplified by large differences in doses due to eye size (see Figure 3) and eye shape (see Figure 4). Additional significant dependence is found in plaque size on the calculated dose in spite of all plaques giving the same dose to the prescription point, although this data is not presented in this poster. The variation in dose with eye shape and size fully justifies the addition of a high resolution ocular CT to the planning technique for patients with unusual ocular anatomy. It is highly recommended that patients whose ocular anatomy present with unusual eccentricities (E≠1) be planned with a high resolution ocular CT to accurately establish accurate doses to normal tissues.

Figure 1: Methods (Top) Setup Window in Plaque Simulator v6.3.1 where the eye size and shape can be modified. The default eye size and shape have an eccentricity of 1.00 and an equatorial diameter of 24 mm.

Figure 2: Variation in dose due to eye size. A COMS 20 plaque was used for this study with right eye modeled at an equatorial diameter of 24 mm. More eccentric eye (E=0.85) displayed larger doses to the sclera, opposite disc, opposite retina, eye origin, macula, and tumor apex.

Figure 3: The effect of dose to normal tissues in the eye with variations in eccentricity. A COMS 20 plaque was used for this study with right eye modeled at an equatorial diameter of 24 mm. More eccentric eye (E=0.85) displayed larger doses to the sclera, opposite disc, opposite retina, eye origin, macula, and tumor apex.

Figure 4: Additional significant dependence is found in plaque size on the calculated dose in spite of all plaques giving the same dose to the prescription point, although this data is not presented in this poster. The variation in dose with eye shape and size fully justifies the addition of a high resolution ocular CT to the planning technique for patients with unusual ocular anatomy. It is highly recommended that patients whose ocular anatomy present with unusual eccentricities (E≠1) be planned with a high resolution ocular CT to accurately establish accurate doses to normal tissues.