Purpose:

The biologically effective dose (BED) of temporary brachytherapy treatments is a function of both chosen radionuclide (R) and implant duration (T). This study endeavored to evaluate BED delivered to the tumor volume and surrounding ocular structures as a function of plaque position (P), prescription dose, R, and T.

Methods:

Plaque-heterogeneity-corrected dose distributions were generated with MCNP5 for the range of currently-available COMS plaques using low-energy radionuclides. These physical dose distributions were imported into the Pinnacle<sup>3</sup> TPS using the TG-43 hybrid technique and used to generate DVHs for a T=7d implant within a reference eye geometry at eight standard treatment positions. The Dale equation was employed to create biologically effective dose volume histograms (BEDVHs), allowing for BED volumetric analysis of all ROIs. Isobiologically-effective prescription doses were calculated for T=5-0.01d, with BEDVHs subsequently generated for all ROIs using correspondingly reduced prescription doses. Objective functions were created to evaluate the BEDVHs as a function of R and T.

Results:

Reducing T from 7 to 0.01d for a 10mm plaque produced an average BED benefit of 26%, 20%, and 17% for <sup>103</sup>Pd, <sup>125</sup>I, and <sup>131</sup>Cs, respectively, for all P; 16mm and 22mm plaque results were more position-dependent. <sup>103</sup>Pd produced a 16-35% BED benefit over <sup>125</sup>I, whereas <sup>131</sup>Cs produced a 3-7% BED detriment, independent of P, T, and plaque size. Additionally, corresponding OAR physical doses were lowest using <sup>103</sup>Pd in all circumstances.

Conclusions:

Shorter implant durations may correlate with more favorable outcomes vs. 7d implants for small and medium lesions. T may be safely reduced if the prescription dose is appropriately diminished. <sup>103</sup>Pd offers a substantial 16-35% radiobiological benefit over <sup>125</sup>I and <sup>131</sup>Cs irrespective of P, T, and tumor size. The objective functions used in this study can be applied to temporary or permanent brachytherapy implants for a variety of disease sites.