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Dosimetric Evaluation of I-125 and Pd-103 Eye Plaques with the EGS-Brachy Code

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1. Introduction

Uveal melanoma comprises close to 4% of all wholle body melanomas, however, it is the most common intraocular cancer in adults. Brachytherapy is one of the preferred methods of treatment of this malignancy because it offers equivalent tumor control to the other practices while allowing eye anathomic preservation and vision function [1].

There are various types of eye plaques and radionuclide sources that have been used for the treatment of ocular tumor in the clinical practice. As example, the standard design of plaques from the Collaborative Ocular Melanoma Study (COMS) consists of a gold-alloy backing and a silastic seed carrier insert. The radioactive seeds are accommodated inside grooves in the convex side of the silastic insert [2].

The main purpose of this study is to present a dosimetric evaluation of the COMS eye plaques loaded with Pd-103 and I-125 radionuclide seeds using the egs-brachy code. The code provided a fast and practical tool to evaluate the eye dosimetry well accepted by physical medical community [3].

2. Methodology

2.1. Eye geometry and materials

The standard COMS plaque design (fig. 1) are available in 10 mm to 22 mm diameters in 2 mm increments. The composition of the gold-alloy backing is 77%, 14%, 8%, and 1% of Au, Ag, Cu, and Pd, by mass weight respectively. The mass composition of the silastic seed carrier is 39.9%, 28.9%, 24.9%, 6.3%, and 0.005% of Si, O, C, H and Pt respectively [2].

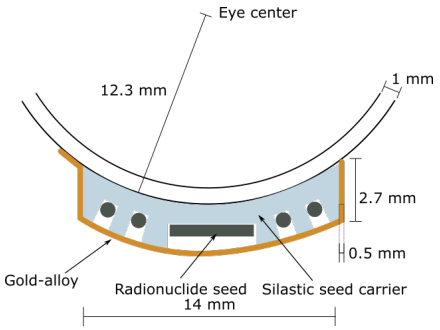

Figure 1: Side view diagram illustrating a 14 mm COMS plaque, on idealized 12.3 mm radius eye.

2.2. Radioactive sources

The I-125 radioactive seed is composed of a cylinder of silver coated with the radionuclide on its surface. This core is covered by a titanium cylinder. The external dimensions are 0.8 mm of diameter and 4.6 mm of length, fig. 2. The Pd-103 seed shares the same external dimensions as the I-125 seed. The radioactive material coats the surface of two graphite pallets. A lead marker is placed in the center. The ends are sealed with two end cups of titanium, fig. 2.

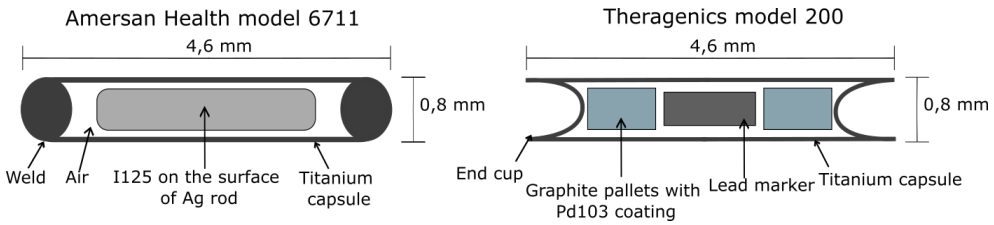

Figure 2: Diagram of the I-125 and Pd-103 seeds with dimensions and material spectifications.

The nuclear decay information of the radionuclides were obtained on the website *National Nuclear Data Center* [5].

2.3. Code input and output

The dose distributions were simulated with adaptations of the input code, seeds_in_xyz, distributed with the egs-brachy code. Plaques and seeds were simulated at the center of a water phantom (30 cm of length in all 3 directions). Doses were scored in a 51 by 51 by 51 voxel grid of 0.000125 cm ^{3}. Dose were only scored where voxels did not overlap with the plaque.

Different scenarios were simulated for the plaques:

- HOMO: Simulation with *Task Group 43* conditions [6]. Plaque and backing modelled as water without the consideration of interseed effects.
- HETERO: Plaques and seeds fully modelled in the water Phantom.

2.4. Validation

The data from *Update of the CLRP eye plaque brachytherapy database for photon-emitting sources* were used for validations of the dosimetric simulations [4]. The validation evaluate the difference of the values of the dose profile on radial axis taken 0 up to 2.5 cm with reference data. Also the mean value over the whole spatial distance was calculated. The simulations contemplated seeds of I-125 and Pd-103 with its respective sizes on both scenarios HOMO and HETERO described previously. The plaques with Pd-103 were evaluated to the 12, 14 and 16 mm diameters.

3. Results and Discussion

The simulation data from the Pd-103 seeds on COMS plate with 12, 14 and 16 mm were intercompared with reference data. The dose difference profiles and their average over plate

axis were depicted in fig. 3. The mean values of the dose difference of the reference and the simulations was 0.18% for the HOMO scenario and 0.03% for the HETERO.

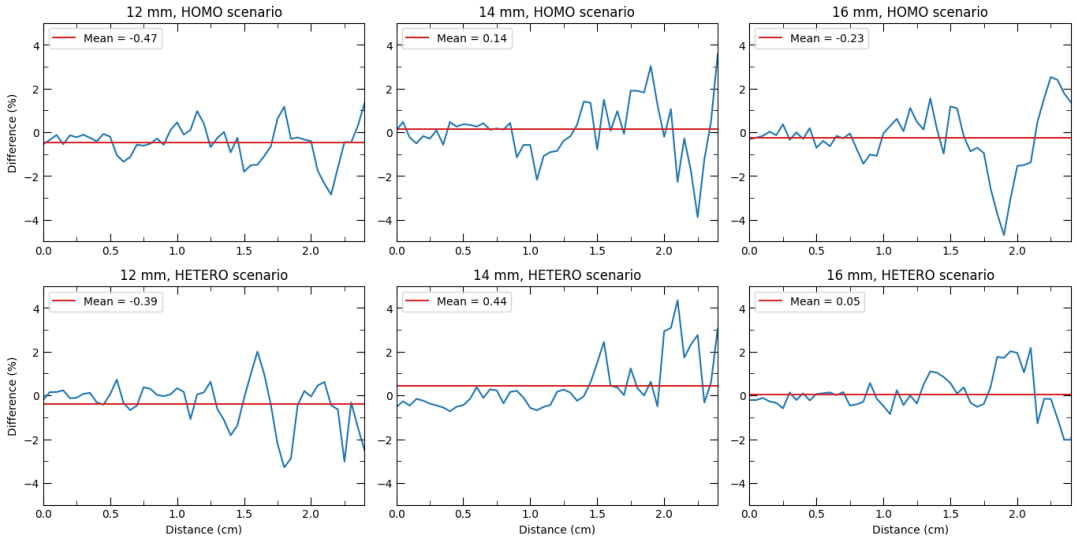

Figure 3: Profiles of the dose difference between simulation values and reference data for COMS plate with Pd-103 seeds at 12, 14, and 16 mm diameter in Homo and Hetero scenario.

On the validation processes, similar results were achieved for the I-125 seed in COMS plate. The average difference in the HOMO scenario were 0.04% and in the HETERO was 0.03% for I-125 seeds in COMS plate.

The dose profiles on the central axis for 14 mm diameter COMS plaque holding I-125 and Pd-103 radionuclides are represented in fig. 4.

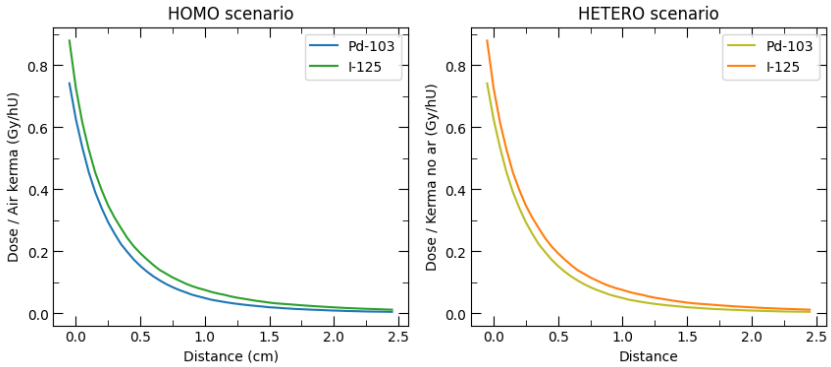

Figure 4: The dose profiles on the central axis of 14 mm diameter COMS plaque for I-125 and Pd-103 seeds in HOMO and HETERO scenario.

The transverse axis dose profiles for 14 mm diameter COMS plaque holding I125 and Pd-103 radionuclides are represented in fig. 5.

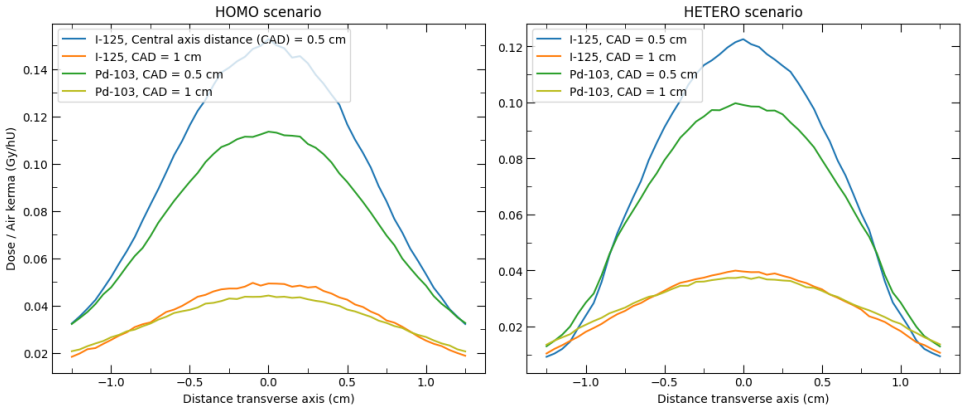

Figure 5: Transverse axis dose profile of 14 mm diameter plaque.

The evaluation of doses on our computational simulations showed that I-125 offers on average a higher dose than Pd-103 on the regions 5 mm near the plaque. Overall, HOMO doses are higher than the HETERO doses, due to the inclusion of the attenuation and scattering from the COMS plaque and seed carrier on the HETERO configuration.

4. Conclusions

The dosimetry evaluation based on EGS-brachy computational simulations, presented in this study, showed that the Pd-103 and I-125 radionuclide seeds have distinct dosimetric properties that can be explored in the clinical practices in order of set up better treatments. This study also shows the importance of considering the heterogeneities presented by the eye anatomy and plaques for the dose calculation accurately.

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