

Measured, calculated and Monte Carlo simulated dose distributions in a unique gold applicator loaded with I-125 seeds

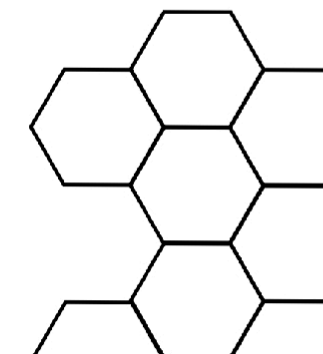
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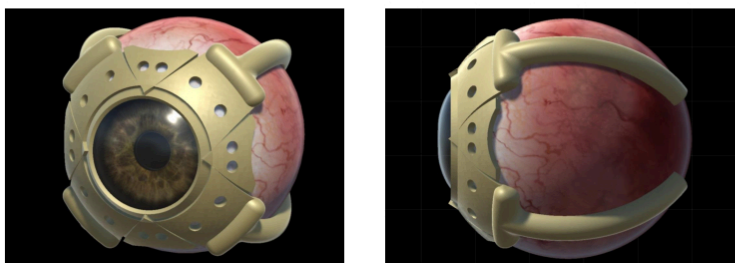
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INTRODUCTION

The “Claws” is a unique gold applicator for whole-eye radiotherapy that is used to treat retinoblastoma. Under general anaesthesia a pericorneal ring is attached to the four extra-ocular muscles and four legs, each loaded with I-125 seeds, are inserted in-between each pair of muscles and attached anteriorly to the ring. The applicator irradiates the eye with minimal dose to the surrounding bony orbit, extra-ocular optic nerve and eyelids. Certain seeds may be omitted to reduce the dose to the unaffected parts of the eye. A typical treatment prescription is 40 Gy given over 4 days to the centre of the eye.



AIM

The aim of this study was to compare measured, calculated and Monte Carlo simulated dose distributions in the applicator.

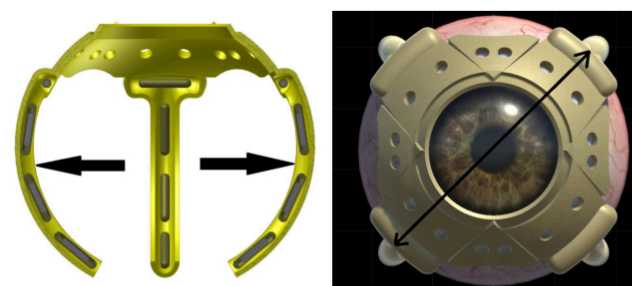
METHOD

The OncoSeed 6711 I-125 seed was used for all measurements, calculations and simulations. Gafchromic film (EBT2 & EBT3) and thermoluminescent dosimeters (TLD700 – 3x3x0.9mm) were used for dose distribution measurements in solid water eye phantoms. Dose distributions were also calculated on two treatment planning systems (TheraPlan Plus Version 3.8 Build 500 (TPP) and Varian BrachyVision Version 15.6.05 – TG43 formalism for point and line source). egs_brachy was used to run a 64,000,000,000 histories Monte Carlo simulation to determine the dose distribution in and around the “Claws”. Voxel sizes were 0.1x0.1x0.1mm.

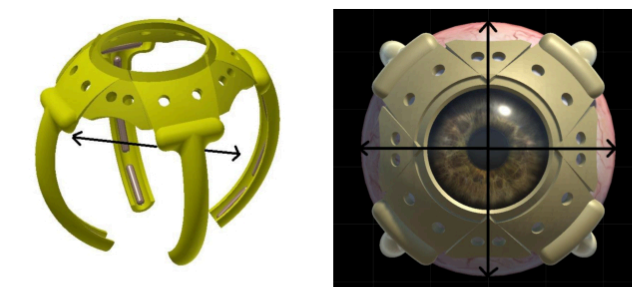


RESULTS

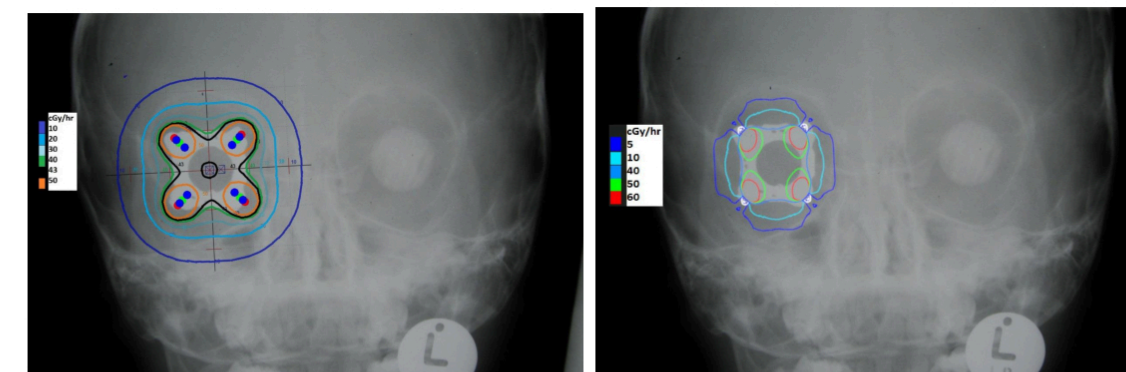
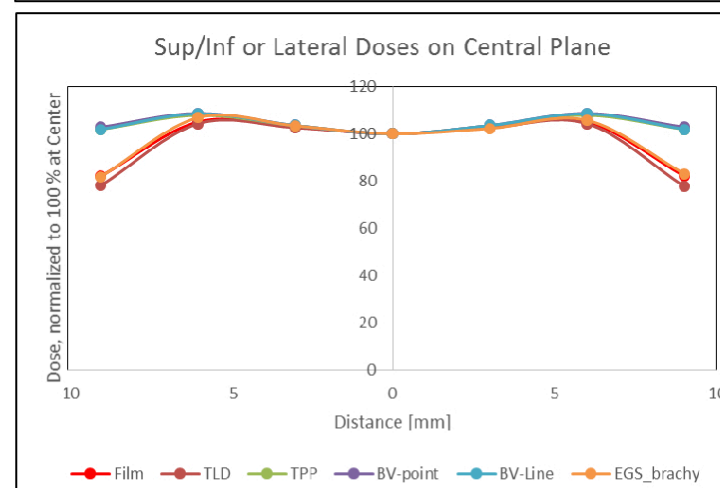
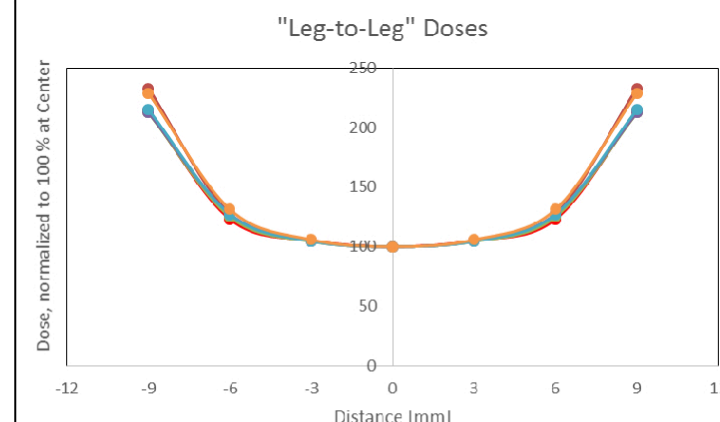
Results are shown for two measurement planes in the eye



“Leg-to-Leg” Dose Plane Indication
Doses normalized to 100 % at the center of the eye



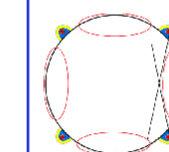
Sup/Inf or Lateral Doses on the Central Plane
Doses normalized to 100 % at the center of the eye



TPP calculated dose distribution (left) vs egs_brachy calculated dose distribution (right). Dose distributions in the central plane are superimposed an X-ray of the “Claws” in-situ. The treatment planning systems cannot take the gold shielding of the applicator into account, but the effect of the shielding is obvious in the egs_nrc results.

It can be seen that the measured, calculated and simulated doses on the “Leg-to-Leg” plane match each other quite well. There is a slight mismatch near the seeds closest to the legs, the maximum difference is 8.7 %.

On the Sup/Inf or Lateral profiles the following is seen: The calculated doses (TPP, BrachyVision Point Source, BrachyVision Line Source) match each other and indicate an almost flat profile hovering near the central prescription dose. Measured TLD and film data match the egs_brachy simulated data, but do not match the planned data near the periphery of the eye. Differences of up to 20 % are seen. The treatment planning systems cannot take the gold shielding into account and therefore calculate significantly higher doses in those regions.



Cross-section through the “Claws, showing the recessed seeds in the legs. Dose is reduced in the red regions

CONCLUSIONS

“Leg-to-Leg” profiles showed good correlation between measured, calculated and Monte Carlo simulated dose distributions.

The profiles along a Sup/Inf or Lateral cut, identical because of the cylindrical symmetry of the “Claws”, showed substantial differences of up to 20 % between calculated data vs. measured and simulated data. The reason for this is the partial occlusion of the I-125 seeds, because they are recessed in the legs of the “Claws”. Neither TPP nor BrachyVision have the ability to include the gold shielding in their brachytherapy dose calculation. This substantial dose difference was not known and may have clinical implications, with potential underdosing of cancerous tissue near the periphery of the eye.

The Monte Carlo simulations allowed a correct visualization of the dose outside of the eye for the first time.

A discussion with the ophthalmic oncologist is needed to decide whether the “Claws” design needs some changes to reduce the gold shielding to the periphery of the eye. Shallower legs will reduce the partial shielding of the sides of the eye, which could potentially improve the clinical outcome of patients.

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