DOSIMETRIC VALIDATION OF THE AGX-100 I-125 SEEDS FOR ROPES EYE PLAQUE BRACHYTHERAPY

CLAIRE PAGULAYAN, SOO MIN HENG, STEPHANIE CORDE

[1]NELUNE COMPREHENSIVE CANCER CENTRE, PRINCE OF WALES HOSPITAL, SYDNEY, AUSTRALIA

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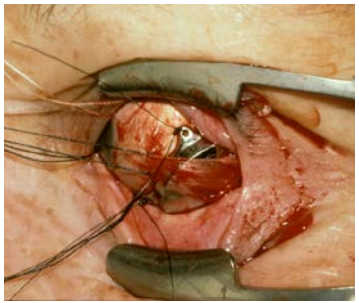
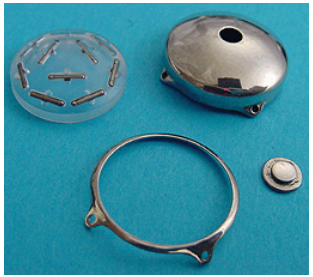
INTRODUCTION

- I-125 eye plaque brachytherapy is most commonly used to treat uveal melanoma (iris, ciliary muscle and choroid).
- The ROPES (Radiation Oncology Physics and Engineering Services Australia) plaque is available in multiple sizes and attachment methods (lugs, flange, notched).
- ROPES plaques used at POWH include; 11 mm, 15 mm flange, 15 mm lugs, 15 mm notched and 18 mm lugs.



(a)



(b)

Figure 1 – (a) ROPES eye plaque insertion. (b) The 15 mm ROPES eye plaque including, dummy plaque, seed carrier Perspex insert, backing and ejector plug.

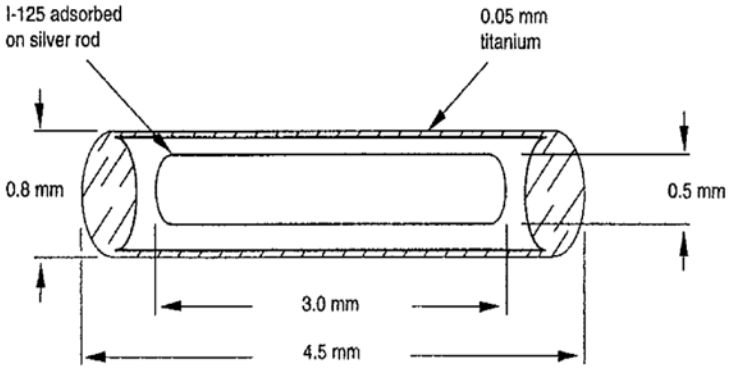
INTRODUCTION

- Theragenics Corporation purchased the Oncura™ brachytherapy line from GE Healthcare, October 2016.
- Distribution of I-125 Oncoseed model 6711 was ceased in Australia.
- Limited dosimetry parameters for AgX™100 I-125 seeds based on TG-43 dose calculation, early 2017.

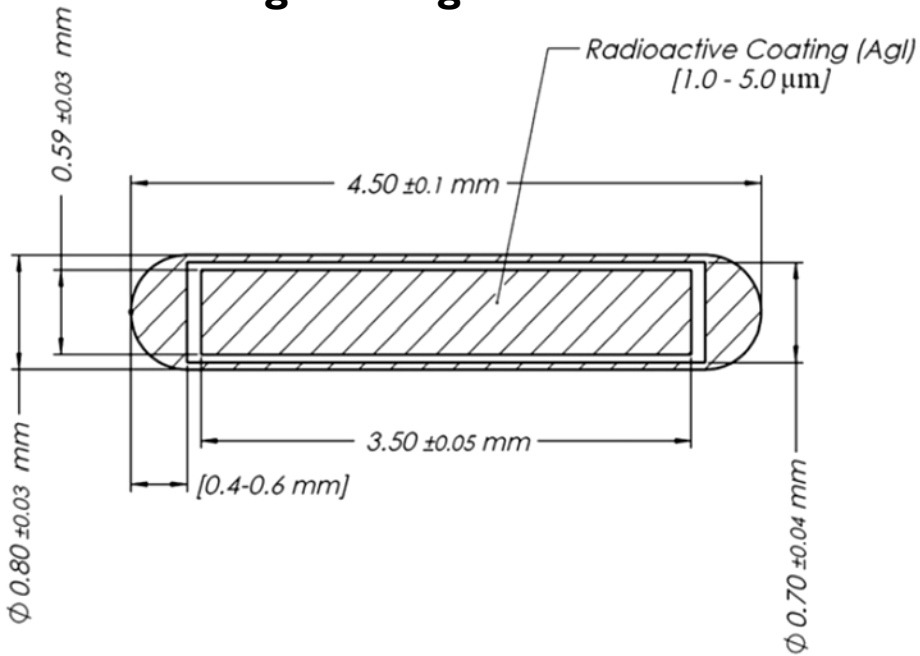
Figure 2 – The AgX100 low dose rate brachytherapy radioactive seed.

PHYSICAL DIMENSIONS

Oncura Oncoseed (model 6711)



Theragenics AgX-100 seed



PURPOSE

- To validate the AgX™100 I-125 seeds for ROPES eye plaque brachytherapy.
  - Assess AgX™100 I-125 seeds before they were accepted for clinical use using independent calculation systems (Plaque Simulator, RADCALC) and film dosimetry.

METHODS

- Verification of AgX100 seed for use in ROPES eye plaques:
  1. Implementation in TPS (Plaque Simulator)
  2. Independent check (RadCalc) and comparison to TPS
  3. Film dosimetry measurements and comparison to TPS

METHODS: BEBIG PLAQUE SIMULATOR (PS) V6.4.6

Treatment Planning System:

- Plaque Simulator™ (BEBIG, Germany) is used to calculate the treatment times for eye plaque insertions.

- Dose calculations in PS based on TG43 data and formalism for radioactive sources.

Upgrade:

- Plaque Simulator software upgraded from v6.0.4 to v6.4.6:
  a) To implement AgX100 seed model.

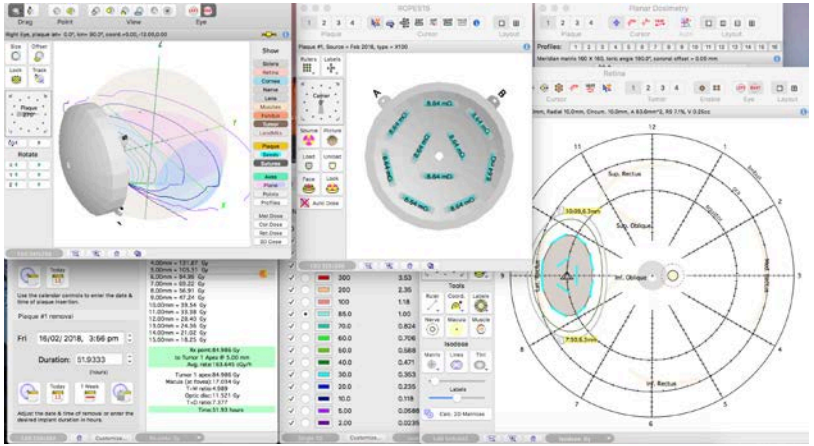


Figure 3 – Screenshot of the graphical user interface (GUI) for the Plaque simulator TPS software.

METHODS: MODELLING AGX-100 SEED

Verify Upgrade:

- Dose calculations performed on existing plans to ensure the upgrade did not have any significant effects.

Modelling:

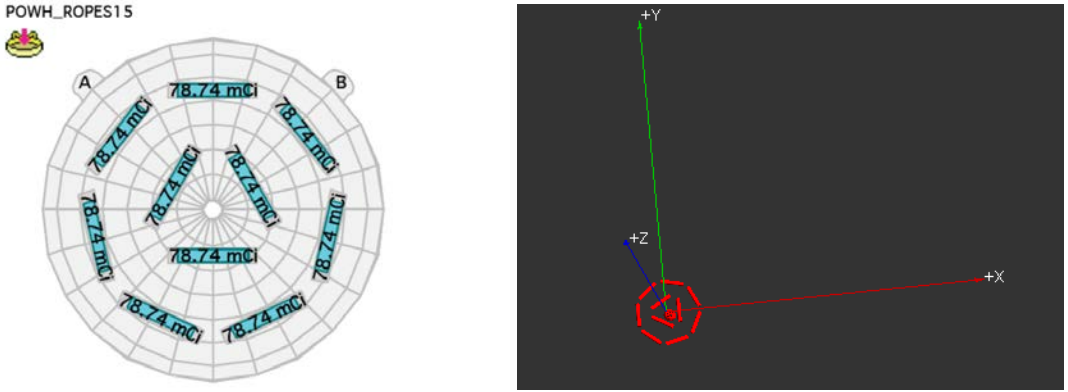
- Dose Rate Constant in PS used the average value of published data,
  $\Lambda = 0.953\ \mathrm{cGy/(U \cdot h)}$
- Anisotropy data used was published by Mourtada et. al. for $0.25\mathrm{cm} \leq r \leq 5\ \mathrm{cm}$
  - Linearly interpolated from 0° to 90° in steps of 1°
- Radial function data used in PS was published by Mourtada et. al for $r \leq 4\ \mathrm{cm}$
  - Linearly interpolated in steps of 0.02 mm

- Chen Z et al. Brachytherapy 2012; 11: 476-482
- Mourtada F et al. Brachytherapy 2012; 11: 237-244

METHODS: INDEPENDENT VERIFICATION

Standard plans

- Standard treatment plans were created in PS v6.4.6 and RadCalc:
  - 11 mm, 15 mm, 15 mm (notched) and 18 mm eye plaques
  - Treatment time: 1 hour
  - Treatment depth: 0 mm (sclera) to 10 mm
  - Seed activity: 100 U (78.74 mCi)
  - Seed type: AgX100 I-125



(a) (b)

Figure 4 – (a) Seed arrangement in PS. (b) Seed arrangement in RadCalc.

Compared results of standard plans calculated using Plaque Simulator and RadCalc.

METHODS: FILM DOSIMETRY

- All film measurements were performed using EBT3 Gafchromic Film (Ashland Inc., Wayne, NJ, USA).
- Calibration films were irradiated using a Therapax DXT 300 orthovoltage unit up to 2 Gy:
  - 10 x 10 cm^2 cone, 50 cm SSD, 75 kVp, HVL 2.63 mm Al
- Two sets of EBT3 Film measurements were conducted to verify the accuracy of the TPS:
  i. Single AgX100 seed in Solid Water
  ii. 15 mm ROPES eye plaque loaded with ten AgX100 seeds

Figure 5 - EBT3 calibration films.

METHODS: FILM DOSIMETRY PHANTOMS

i)

- Measured the dose rate for a single AgX-100 seed using EBT3 film in a Solid Water block phantom with backscatter 5 cm.

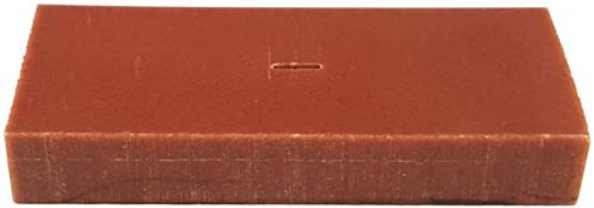


Figure 6 - Single seed Solid Water phantom.

ii)

- Custom made Solid Water eyeball phantom with diameter of 24 mm, cut into 2 mm slices.

Figure 7 - Solid Water eyeball phantom for plaque measurements.

METHODS: EXPERIMENTAL SETUP - ROPES

- Ten 11.29 mCi AgX100 seeds loaded into a 15 mm ROPES eye plaque.
- 5 x 5 cm^2 pieces of EBT3 film at depths 4 mm, 6 mm, 8 mm and 10 mm.
- Each measurement had 5 cm Solid Water backscatter and an enclosed water phantom was placed on top of the plaque for full water scatter conditions.
- PS v6.4.6 prescription dose =1 Gy.
  - Times ranged between 49-106 min

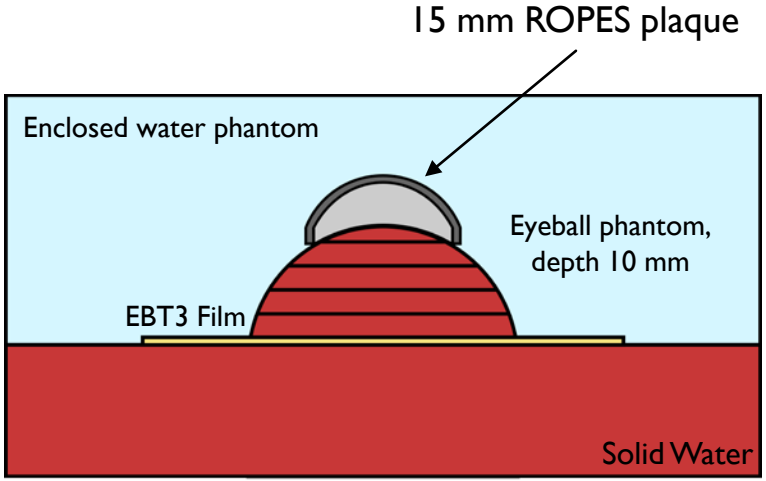
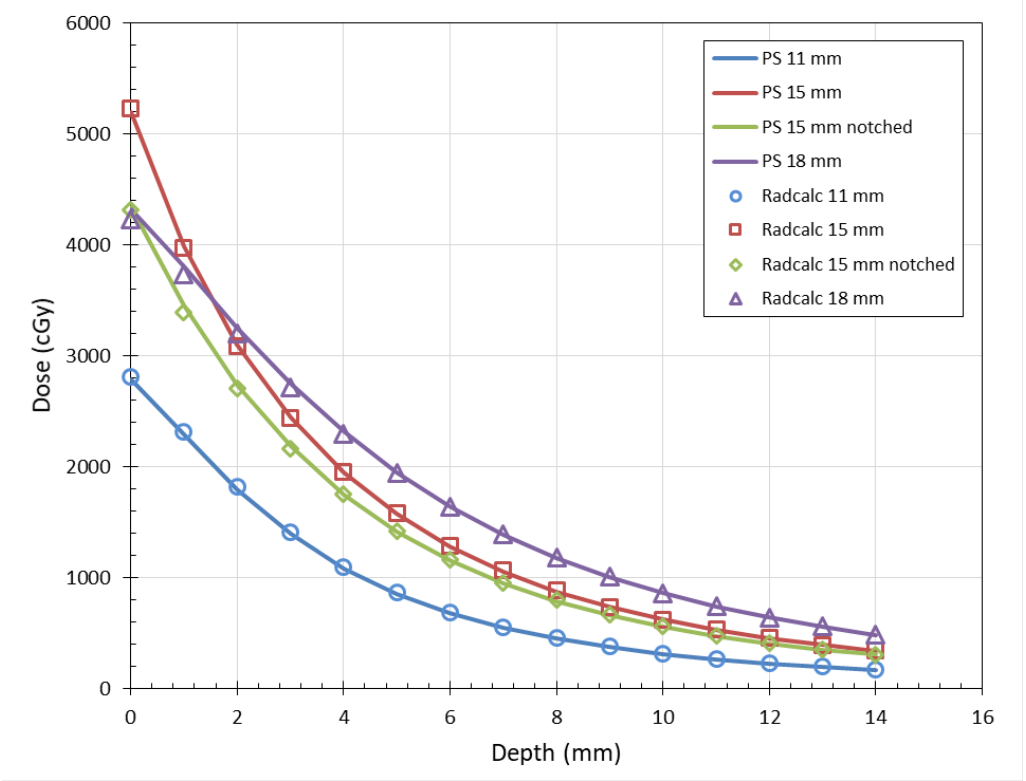


Figure 8 - Schematic diagram of ROPES plaque measurements

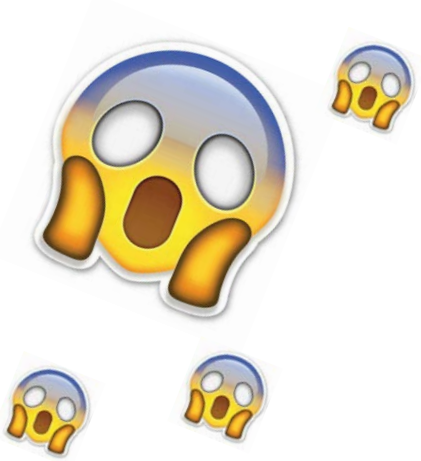
RESULTS: PS VS RADCALC



RESULTS: DOSE CALCULATIONS

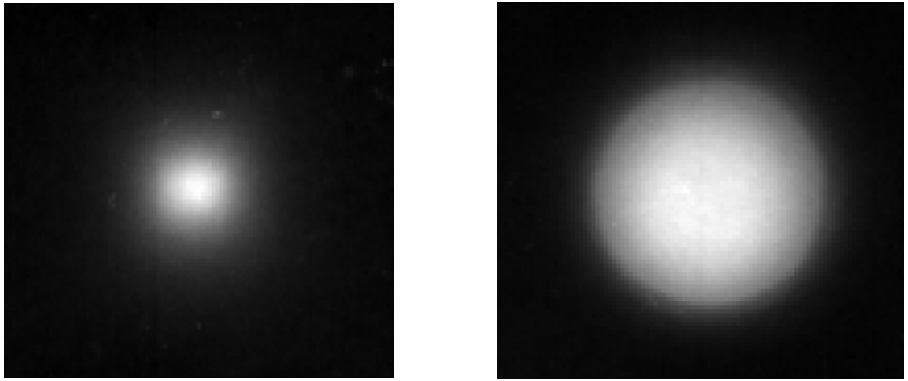
Comparison of standard plans: PS vs RadCalc

Tumour depth (mm)	11mm (cGy)	15 mm (cGy)	15 mm Notched (cGy)	18mm (cGy)
0 (inner sclera)	-0.7%	-0.6%	0.4%	2.1%
1	-1.3%	0.5%	1.8%	1.9%
2	-1.3%	0.3%	1.3%	1.6%
3	-1.0%	0.3%	0.8%	1.3%
4	-0.8%	0.1%	0.2%	0.9%
5	-1.0%	-0.3%	-0.2%	0.4%
6	-1.0%	-0.5%	-0.4%	0.1%
7	-1.1%	-0.7%	-0.7%	-0.2%
8	-1.1%	-0.7%	-0.8%	-0.3%
9	-0.9%	-0.6%	-0.8%	-0.4%
10	-0.8%	-0.6%	-0.9%	-0.4%



RESULTS: FILM

- EBT3 film was post-scanned 24 hours after irradiation.
- Film analysis was performed using net optical density method to calculate dose planes.
- Mean dose measured in a small ROI surrounding CAX for each depth.
- Solid Water correction factor 1.038 applied to all measurements.



(a) (b)

Figure 9 – (a) Single seed EBT3 film (3.63 mm depth)
(b) Loaded ROPES plaque EBT3 film (4 mm depth)

RESULTS: SINGLE AGX-100 SEED

Depth (mm)	EBT3 film Dose (cGy)	PS Dose (cGy)
6.6 ± 0.2	25 ± 1	25
3.6 ± 0.2	79 ± 3	83

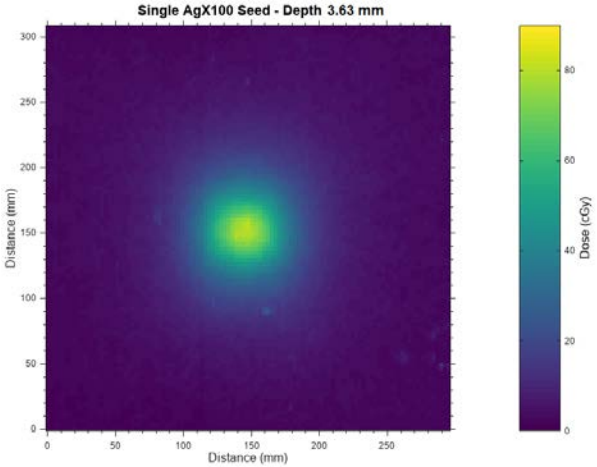
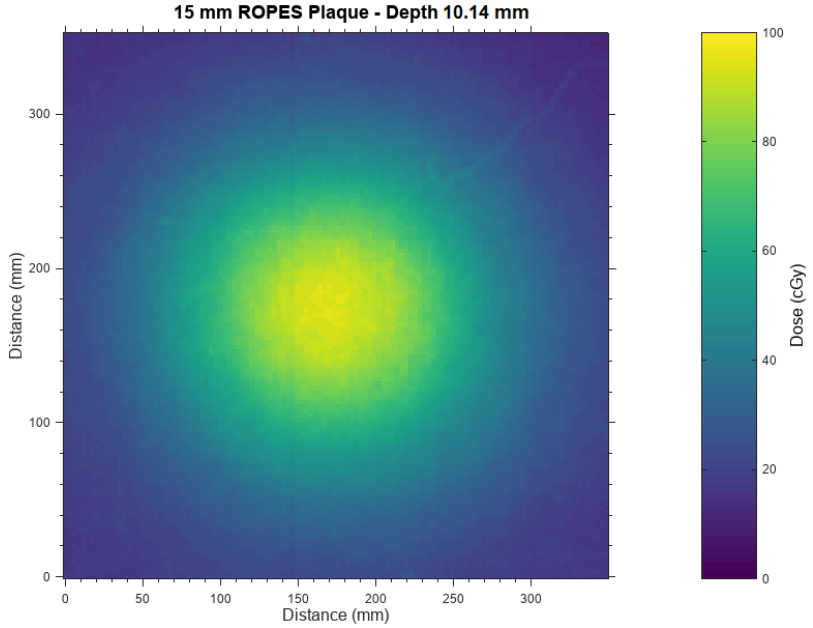


Figure 10 - Experimental set-up of single AgX100 seed measurements

RESULTS: 15 MM ROPES PLAQUE

Depth (mm)	PS Dose (cGy)	EBT3 Film Dose (cGy)	% diff to PS
4.1 ± 0.2	146 ± 6	149.98	1.6
6.1 ± 0.2	94 ± 4	97.36	0.8
8.1 ± 0.2	96 ± 4	98.09	2.4
10.1 ± 0.2	98 ± 4	98.09	3.7



CONCLUSIONS

- Plaque Simulator v6.4.6 was found to be acceptable for clinical use for the Theragenics AgX100 I-125 seed with the ROPES plaques.
- Independent dose checks were performed using RadCalc v6.2.3.6 for the ROPES plaques and the agreement between Plaque Simulator v6.4.6 and RadCalc is less than 2% for clinically relevant tumour depths.
- Film dose measurements with the 15 mm ROPES plaque confirmed the validity of Plaque Simulator v6.4.6