Preliminary Studies of a New Method for Confirming the Activity of Ru106 Plaques for Uveal Melanoma

M. HAUZE[1], A. PORTOCARRERO BONIFAZ[1], T. Ma[2], and A. WILKINSON[2]
1Cleveland State University, Cleveland, Ohio
2Cleveland Clinic Foundation, Cleveland, Ohio

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
Improving Health QUALITY, Increasing Global IMPACT
EASTERN TIME [GMT-4]

INTRODUCTION

Best practice upon receipt of a new eye plaque is to confirm the reported activity given by the vendor before using it in a clinical setting. For Ru-106 plaques, the standard has been to use film dosimetry in a water-equivalent medium. However, this can be cumbersome and inconsistent. We investigated the use of two other methods: 1. a scintillation detector and 2.a survey meter.

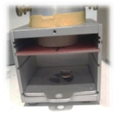
AIM

To test a new method of confirming the activity of Ru-106 plaques used to treat uveal melanoma.

METHOD

- Two batches (one set calibrated on 10/20/17, and the other set on 1/9/20) of three Ru-106 plaques (CCA, CCB, and COB) from Eckert & Ziegler (BEBIG) along with their NIST-traceable calibration certificates, were used.
- Our current protocol is to measure the dose rate at a prescribed depth along the central axis of the plaque in a water phantom using Gafchromic film (EBT2 and EBT3).
- Calibration curves (Dose vs. OD) were obtained by irradiating film with 6 MeV electrons from a TrueBeam LINAC in clinical use.
- Two new methods were studied:
- The **first one** uses a Ludlum Model 44-3 NaI scintillation counter. In this case the measured plaque was placed at the center of the holder at a distance of 4 cm from the probe.
  - A 2 mm sheet of solid water was placed between the end of the probe and the plaque.
  - Orientation of the plaque (rotation and displacement from the center) was varied to determine optimal placement for measurement.
  - The linearity of the readings (counts per minute) was verified for the range of 0.1 - 0.5 minutes with 10 repeated measurements at each time.
  - A "calibration factor" or efficiency was then calculated.
- The **second one** uses a Ludlum 9DP detector. In this case the plaque was placed on a holder 16.5 cm away from the detector.

Method 1: Ludlum Model 44-3



Method 2: Ludlum 9DP detector

RESULTS

Initially, small pieces were cut from EBT 2 film and used for dosimetry. It was noticed that the exposed film lost color to the surrounding water. We then switched to using a full sheet of EBT3 film, and this issue could be minimized, resulting in a measured dose that ranged from -10.87% to 7.96% of the expected dose.

The counts observed using the scintillation method were linear with time. The overall efficiency for the sets of eye plaques used was 0.00147. The highest discrepancy between the expected and the calculated values was 5.45%, while the average discrepancies ranged from 1.81% to 4.30%. However, the new and old sets were not accurate or precise when comparing the two.

The Ludlum 9DP survey meter results were consistent between dates, and between groups. The highest variation in reproducibility was found to be 4.4%; and the calculated values for old and new sources regarding the calibration factor was found to be almost the same.

Film Used:	EBT 3		
Insert Material:	Water		
Time In:	2/28/2020	3:20 PM	
Time out:	2/29/2020	3:11 PM	
Depth (mm):	6.45	6.45	6.20
	CCA - New	CCB - New	COB - New
	0.94	0.94	1.00
	0.92	1.06	1.10
	0.93	1.00	0.99
	0.92	0.96	0.99
	0.90	1.01	1.04
Dose (cGy)	1221.82	1438.47	1534.15
Dose (Gy)	12.22	14.38	15.34
Expected Dose (Gy)	13.71	14.18	14.21
% Error	-10.87	1.42	7.96

Table 1. An example of using the eye plaques to expose a whole piece of Gafchromic film in water. The optical densities measured, along with the corresponding dose measurements are compared to the expected value based on BEBIG's calibration certificate.

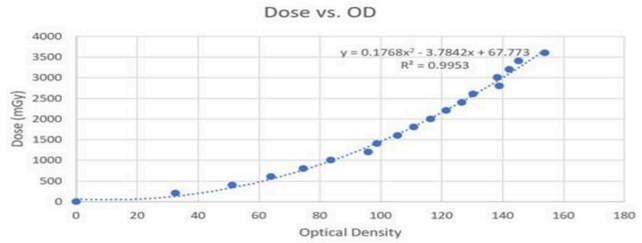


Figure 1. Optical density calibration curve obtained from Gafchromic film irradiated with a Varian TrueBeam Linac.

Counting Time (seconds)	CCA New (cpm/activity in Bq)	CCB New (cpm/activity in Bq)	COB New (cpm/activity in Bq)	CCA Old (cpm/activity in Bq)	CCB Old (cpm/activity in Bq)	COB Old (cpm/activity in Bq)
6	0.00142	0.00151	0.00143	0.00186	0.00226	0.00208
12	0.00142	0.00152	0.00144	0.00186	0.00224	0.00210
18	0.00147	0.00153	0.00144	0.00185	0.00226	0.00209
24	0.00144	0.00155	0.00144	0.00186	0.00225	0.00210
30	0.00147	0.00156	0.00141	0.00186	0.00220	0.00211
Average Efficiency	0.00144	0.00153	0.00143	0.00186	0.00224	0.00209
Overall Efficiency		0.00147			0.00207	

Table 2. Shows the efficiency rate for the sets of old and new eye plaques at five different time segments. The efficiencies for each set were precise, but not accurate when comparing the old set to the new set.

	CCA New	CCA Old	CCB New	CCB Old	COB New	COB Old
Ratio = $R_{decayed} / R_{measured}$	0.422	0.441	0.452	0.449	0.436	0.442
	0.415	0.428	0.440	0.451	0.432	0.434
	0.404	0.427	0.444	0.444	0.431	0.431
Standard Deviation	0.009	0.008	0.006	0.004	0.002	0.006
Average Standard Deviation	0.003					
Average Ratio	0.415		0.444		0.431	
Overall Average	0.430					

Table 3. Shows the ratio of the expected activity based on radioactive decay to the measured activity using the Ludlum 9DP survey meter. The ratios between the new and old plaques of the same model are precise, and accurate when comparing the collective sets of new and old plaques (disregarding model type).

CONCLUSIONS

- The uncertainties found in the scintillation method are similar in size to what was found using film dosimetry.
- The scintillation method is simpler than using Radiochromic films. Nevertheless, inconsistencies in the calculated calibration factors between old and new sources don't make them reliable for our objective.
- Ludlum 9DP survey meter proofed to be most reliable option used to confirm the activity of new sources until better methods are available. It shows a good reproducibility and consistency between old and new sources.

ACKNOWLEDGEMENTS

- Cleveland State University. Medical Physics Program
- Cleveland Clinic Foundation

REFERENCES

Heilemann, G., Nesvacil, N., Blaickner, M., Kostiukhina, N., & Georg, D. (2015). Multidimensional dosimetry of 106Ru eye plaques using EBT3 films and its impact on treatment planning. *Medical Physics*, *42*(10), 5798-5808

Prekeges, J. (2012). Scintillation detectors. *Nuclear Medicine Instrumentation (book)*. Jones & Bartlett Publishers

CONTACT INFORMATION

M. Hauze

Email: mahauze93@gmail.com