The Royal Liverpool and Broadgreen University Hospitals NHS

Occupational Dosimetry During Intra-Procedure Placement and Removal of Ru106 Brachytherapy Sources for the Treatment of Choroidal Melanoma

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Clinical Background

Typically, our trust treats 128 patients per year (averaged over 2009(128 patients), 2010(117) & 2011(141)) using temporary placement of radioactive Ru106 eye plaque brachytherapy sources.
The treatment is indicated for selected Choroidal Melanomas (majority), Conjunctival Melanomas and Choroidal Haemangiomas.

If left untreated, Choroidal Melanoma can[1];
• Cause detachment of the retina leading to blurred or distorted vision, field defects or flashes of light.
• Invade the tissue around the eye by perforating the sclera
• Perforate the retina leading to bleeding in the eye (vitreous haemorrhage) with likely blurred vision and floaters

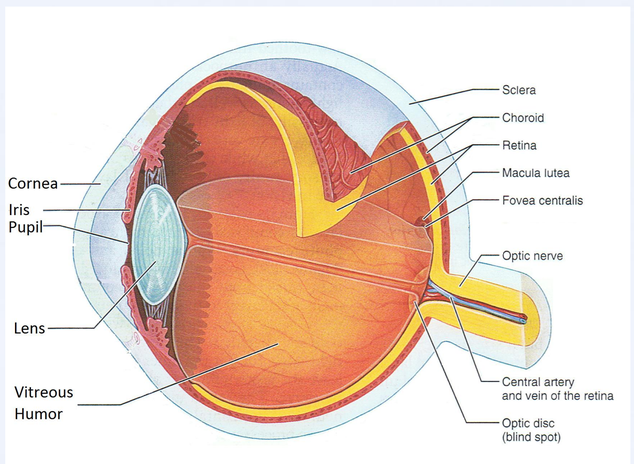

Figure 1: Anatomical diagram of the human eye[2]

Figure 2: Typical Bebig Ru106 Eye Plaque Brachytherapy Source

Treatment Schedule

•Plaque insertion in Ophthalmic Theatre procedure
•Radiotherapy Clinical Scientist notified of insertion time and specific eye plaque source used
•Radiotherapy Clinical Scientist calculates treatment time to deliver prescribed dose to the tumour site
•Plaque is removed in Ophthalmic Theatre procedure

Acknowledgements

Staff at the Liverpool Ocular Oncology Centre for which the measurements were made originally.
Royal Liverpool University Hospital Medical Illustration Department (photo of a typical Ru106 Eye Plaque)
National Physical Laboratory for Brachytherapy source dosimetry validation

References

[1]Liverpool Ocular Oncology Centre website www.eyetumour.co.uk/ocular_tumours.php
[2] (manipulated diagram from) Marieb.,E.N. ,Human Anatomy and Physiology, 2001 (fifth edition), Addison Wesley Longman.
[3] Bebig Certificate for Sealed Radioactive Source (RLUH source document archive)
[4] Bebig Ru106 Ophthalmic Plaques Product Information, www.ibt-bebig.eu

Practical Considerations

• Dose rates in excess of 100mGy/min[3] are observed in close proximity (0.6mm) from the centre of the treatment surface

•Dose rates are independently validated by measurement at the National Physical Laboratory (Teddington, UK)

•Therefore manipulation and close contact time by theatre staff must be minimised to reduce occupational dose

•Source(s) emit Beta radiation and therefore Perspex should be considered for shielding purposes

• Several episodes of plaque manipulation: before placement (sterialisation), during placement, during removal, during cleaning and drying

•Non-radioactive plaques are used by the surgeon during placement and alignment to minimise exposure to the extremities from the actual source to be used

•Potential decrease in Dose Limit for Lens of the eye

Ru106 Ophthalmic Plaques

Ru106 Physical characteristics[4]
•Half Life = 374 days
•Beta decay
•Maximum Beta energy = 3.54MeV

Plaques used at the Liverpool Ocular Oncology Centre at the Royal Liverpool University Hospital are complete circular concave units with diameters (D) of 15mm, 20mm and 25mm.

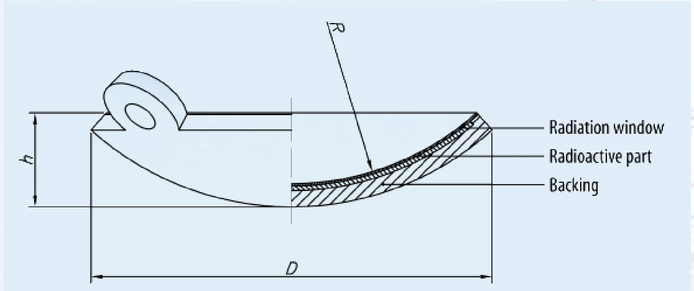

Figure 3: Diagram of the eye plaque configuration[4]

Each plaque has a fine film of Ru106 encapsulated in pure silver. The concave side is coated with 0.1mm silver foil (Radiation window) and the Backing (0.9mm) attenuates approximately 95% of the Beta radiation. Radii (R) vary from 12 – 14mm.

Ionising Radiations Regulations 1999

Occupational dosimetry:
Approved Dosimetry Service (ADS) measurement of occupational exposures arising from Ru106 eye plaque treatments. Issued 6/year
Film badges: Whole body Effective Dose
Thermo-luminescent Dosimeters (TLD): Equivalent dose to upper extremities (fingers)

The Local Investigation Levels defined in the Local Rules for Radiation Safety are 2mSv/year (Whole Body Effective Dose) and 50mSv/year (Equivalent Dose to upper extremities)

Periodic Risk Assessment Review:
Dose rates during placement and removal of Ru106 eye plaques were recorded using a calibrated Mini-Monitor Series 900 Dose Rate Meter.

Conclusions

With multiple staff spreading the dose, a large throughput of patients can be treated for Choroidal Melanomas, Conjunctival Melanomas and Choroidal Haemangiomas using Ru106 Brachytherapy eye plaque sources without any individual employee exceeding the Local Investigation Level for either Whole body Effective Dose or Equivalent Dose to the upper extremity.
Dose rate review is a good method to estimate doses and highlight areas to improve radiation protection practise.

Occupational Dosimetry

ADS Results
Typically, Surgeons manipulate the plaques into position and remove the plaques following completion of the treatment time and all other manipulation (including preparation for sterilisation, subsequent cleaning and return to the security cupboard) is carried out by nursing staff and support staff. Therefore the results have been divided into Surgeons and Non-Surgeons.

	Dose	2011	2010	2009
Surgeons	WB	0.0	0.0	0.0
Non-Surgeons	WB	0.0	0.0	0.0
Surgeons	ULE	1.15	1.80	0.76
Non-Surgeons	ULE	3.24	6.65	8.84
Surgeons	URE	2.20	1.64	0.49
Non-Surgeons	URE	3.10	5.88	8.20

Figure 4: ADS Results for Eye-Plaque therapy work. Whole Body Effective Dose (WB) and Upper Extremity Equivalent Doses to the Left (ULE) and right (URE) sides for the full annual periods of 2009-11 are all expressed in mSv.

Whole body dosimetry did not register a single measurable value in the period 2009-11. (Minimum recordable 2-monthly measurement threshold of 0.10mSv). Despite some moderate change in numbers of procedures during the same period, Extremity Equivalent Doses were observed to decrease for non-surgical staff. Suggesting improved Radiation Protection practise, increased awareness and less time in close contact with the sources. Surgical staff equivalent doses were more stable between 2010-11. The increase between 2009-10 could be increased awareness and utilisation of TLD dosimeters.

Intra Procedural Measurements
Dose rates observed when manipulating specific Ru106 eye-plaques of known activity and approximate durations of close contact were applied to estimate the typical occupational dose received for placement and removal procedures.

Procedure	Plaque Activity (MBq)	Dose Rate (µSv/hr)	Duration (mins)
Loading of the plaque to the sterilisation tray using perspex screen	12.68	20	< 1
Transportation of plaque to Sterilisation (no shielding)	12.68	100	0.2
Adjacent to Autoclave unit	22.70	10	20
1 meter from Autoclave unit during sterilisation	22.70	<1	20
Adjacent to surgeon's fingers during placement	4.79	40	4
Adjacent to surgeon's eyes during placement	4.79	1.5	4
Adjacent to the eye patch on the patient following placement	4.79	30	Not specified
4cm from plaque prior to removal (no patch)	22.70	100	0.5
30cm from plaque prior to removal (no patch)	22.70	20	0.5
Surface of water during cleaning process (no shield)	22.70	80	4
Cleaning process following removal (perspex shield)	22.70	10	4
Air drying period following cleaning (perspex shield)	22.70	20	15

Figure 5: Selected Dose Rate measurements and estimates of likely doses from associated activities involving Ru106 eye plaques

The highest activity sources used clinically are marginally over 40MBq (25mm diameter plaque) and the lowest activity can be as low as 4MBq (15mm diameter plaque). Therefore the observed dose rates for a specific element of a procedure can vary greatly.

Considering observed dose rates and approximate time allocation per task the equivalent dose of 57µSv is likely to be delivered to the surgeon's fingers during placement (7µSv) and removal (50µSv) of a 22.7MBq Ru106 plaque.

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