EYE PLAQUE TEST CASE:

User Guide for Elekta Brachytherapy ACE© Algorithm Testing

Contents

I. Introduction

The American Association of Physicists in Medicine (AAPM) Task Group 186 report [1] provided general guidance for early adopters of model-based dose calculation algorithms (MBDCAs) for brachytherapy (BT) treatment planning. The report's aim was to facilitate uniformity of clinical practice. Among its recommendations was a two-level approach to commissioning MBDCAs embedded in BT treatment planning systems (TPSs) insofar as specific tasks relating to the dose calculation algorithm are concerned. In commissioning level 1, the clinical physicist should assess agreement of MBDCA TPS-derived absolute dose or dose rate with the dose or dose rate obtained in the TPS using AAPM-recommended consensus TG-43 dosimetry parameters for a given BT source model. In commissioning level 2, the physicist should compare 3D dose distributions calculated with the MBDCA-based TPS for specific virtual phantoms mimicking clinical scenarios against benchmark dose distributions derived independently from the same phantom geometries.

The AAPM Working Group on Dose Calculation Algorithms in Brachytherapy (WG-DCAB) [2] was created to facilitate implementation of the recommendations for MBDCA commissioning made in the TG-186 report. Its main charge is to develop test cases including those for realistic clinical scenarios to facilitate commissioning of MBDCAs incorporated in clinical treatment planning systems, and to allow users to independently assess potential differences expected in moving from the current TG-43-based standard of clinical practice in treatment planning dosimetry to the use of a MBDCA. Test Cases for high dose rate Ir-192 BT sources have been described elsewhere [3].

This user manual provides guidelines for level 2 testing of a research version of the Elekta Brachytherapy ACE© Algorithm for eye plaque brachytherapy [4]. To do so the Collaborative Ocular Melanoma Study (COMS) 16-mm eye plaque containing 13 model 6711 I-125 seeds is considered. Five test cases were designed including: modelling a single seed in water (1), the 13 seeds individually and in combination in water (2, 3), the full plaque in water (4), and the full plaque in a realistic eye phantom (5). Although a brief description of the Test Cases will be given in the following, a complete description and analysis can be found in [5]. Only test cases 1, 4 and 5 can be tested with OcB.

II. Eye Plaque Test Cases

A. Accessing the Test Case Repository

The eye plaque test cases are available from the IROC Houston repository at https://doi.org/10.52519/00005 .

B. Downloading the Eye Plaque Cases

Navigating the "Click for cases" tab allows access to download links for the eye plaque test case files. Selecting a link will initiate downloading of the corresponding zip file to your local computer.

These include:

- "Reference MC", and there "Test Case N" containing CT images of the computational eye plaque model, the RT structure set (RS), RT plan (RP) and corresponding RT dose (RD) calculated using Monte Carlo simulations (EGSnrc), in DICOM RT format,
- "Reference TPS", and there "Test Case N" containing the same files as above but with RD data corresponding to reference results using the ACE© algorithm for Test Cases 4 and 5.

A link to download "MC input files" containing the input files used for preparing and benchmarking the reference RD data is also provided for interested users. A link to download all the above files in a single zip file is also provided for convenience.

C. The Eye Plaque Cases

Test case 1 simulated a single seed centered at the origin and aligned along the y-axis in a cubic water phantom. Test case 2 simulated TG-43 conditions where the seeds were positioned in the same water phantom as they would be in the 16-mm COMS plaque, but the plaque backing and insert were not included. Interseed effects were also neglected. Test case 3 was identical to the second one, but interseed effects were included. Test case 4 simulated a fully-modelled eye plaque. All seeds were included with interseed effects. Absorbed dose was scored in the same water phantom as above. The full plaque was simulated in Test case 5 with an anatomically realistic eye phantom.

III. Research version of the Elekta Brachytherapy ACE© Algorithm for eye plaque brachytherapy

A modified research version of the Oncentra Brachy (OcB) Advanced Collapsed cone Engine (ACE), v4.6 has been developed. A complete description of its performance and properties can be found in [4,6]. Briefly, the main differences of this version with respect to the current commercial one are:

- The Oncura model 6711 seed was added to OcB for use with the TG-43 formalism and for ACE as determined by the Carleton Laboratory for Radiation Physics group.
- The 16-mm COMS plaque model was incorporated into the OcB applicator library via processing of three-dimensional CAD drawings of the plaque itself.
- A more complete user-defined CT calibration was provided, being derived from a Catphan 600 phantom acquired on a Toshiba Aquillon-64 scanner.
- A smaller dose calculation grid size was required (0.5x05x0.5 mm^3).
- The default number of cones/transport directions for high-accuracy mode was used for all calculations, i.e. 1620/320 for first- and multiply-scattered dose components for the single seed case (test case 1), and 720/240 for first- and multiply-scattered dose components for the multi-seed cases (test cases 4 and 5).

The manufacturer has indicated its willingness to provide a research version, or access to, of OcB to any clinical physicist who wishes to perform Eye Plaque MBDCA calculations upon signing a statement clarifying that such a system is not cleared for direct clinical use. Interested users should contact his/her Elekta representative or the chair of the WG-DCAB.

APPENDIX II: Level 1 and Level 2 commissioning

The following table summarizes statistical results for the local and global dose differences, with egs_brachy results used as the reference, for OcB and three other MC codes. The first three data columns give the ranges of $\%\Delta D_{global}$ between which 95% of the voxels are contained, the means of the $\%\Delta D_{global}$ distributions, and the position of the peaks in the $\%\Delta D_{global}$ distributions. The next three columns give the same data for the $\%\Delta D_{local}$ distributions. For test case 5, only voxels containing eye media were included in the comparisons.

		$\%\Delta D_{global}$			$\%\Delta D_{local}$		
		Range	**Mean**	**Peak**	**Range**	**Mean**	**Peak**
Test case 1 (single seed in water)	MCNP	-0.83, -0.02	-0.09	-0.1	-1.72, -0.81	-1.18	-1.2
	Penelope	-0.59, 0.55	0.04	0.0	-1.82, 1.77	0.75	1.3
	TOPAS	-0.28, -0.02	-0.09	-0.1	-1.32, -0.37	-0.78	-0.9
	OcB	-0.08, 0.30	0.16	0.1	-0.12, 4.72	2.35	2.2
Test case 2 (TG-43)	MCNP	-1.89, -0.05	-0.38	-0.2	-1.43, -0.79	-1.11	-1.2
	Penelope	-0.86, 0.83	0.10	0.1	-0.95, 1.68	0.72	1.0
	TOPAS	-0.78, -0.03	-0.21	-0.2	-1.37, -0.30	-0.77	-0.8
Test case 3 (interseed effects)	MCNP	-1.82, -0.05	-0.37	-0.2	-1.40, -0.78	-1.10	-1.2
	Penelope	-0.91, 0.78	0.08	0.1	-1.05 1.65	0.68	1.0
	TOPAS	-0.79, -0.02	-0.21	-0.1	-1.53, -0.18	-0.77	-0.7
Test case 4 (plaque in water)	MCNP	-1.52, -0.03	-0.25	-0.1	-2.13, -0.72	-1.15	-1.1
	Penelope	-0.47, 0.47	0.07	0.0	-1.11, 2.45	0.80	0.9
	TOPAS	-0.44, 0.00	-0.11	-0.1	-2.50, 0.05	-0.74	-0.5
	OcB	-0.22, 8.55	1.81	0.0	-4.10, 23.46	9.86	8.0
Test case 5 (plaque in eye – eye media only)	MCNP	-3.62, -0.11	-0.67	-0.2	-2.39, 1.62	-1.93	-2.0
	Penelope	-0.84, 0.95	0.10	0.0	-1.32, 2.00	0.55	0.7
	TOPAS	-0.62, 0.19	-0.08	-0.1	-1.43, 1.15	-0.19	-0.2
	OcB	-5.30, 3.56	0.83	0.6	-4.59, 18.78	5.65	4.0

References.

[1] L. Beaulieu et al., “Report of the Task Group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: Current status and recommendations for clinical implementation”, Med. Phys., 39,. 6208–6236, 2012, doi: 10.1118/1.4747264.

[2] “WGDCAB.” [Online]. Available:

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[3] L. Beaulieu et al. “AAPM WGDCAB Report 372: A Joint AAPM, ESTRO, ABG and ABS Report on Commissioning of Model-Based Dose Calculation Algorithms in Brachytherapy”, Med Phys., 1-15, 2023, doi: 10.1002/mp.16571.

[4] H. Morrison et al., “Advanced Collapsed cone Engine dose calculations in tissue media for COMS eye plaques loaded with I-125 seeds”, Med. Phys., 45, 3349-3360, 2018, doi: 10.1002/mp.12946.

[5] E. M. Fletcher et al. “Generation of 3D dosimetric reference datasets for COMS eye plaque brachytherapy using model-based dose calculations”, Med. Phys. 2023, To be published

[6] H. Morrison et al., “Initial evaluation ofAdvanced Collapsed cone Engine dose calculations in water medium for I-125 seeds and COMS eye plaques”, Med. Phys. 45, 1276–1286, 2018, doi: 10.1002/mp.12776.