Initial experience with Mobius3D secondary dose calculations for HDR brachytherapy

J. HUANG, M. LAWLESS, J. MILLER, and C. WALLACE
University of Wisconsin, Madison, WI

JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

Though AAPM's Task Group 40 on comprehensive quality assurance recommends that an independent dose calculation to at least one critical point be performed with brachytherapy implants,[1] performing a secondary dose calculation in a meaningful and efficient way can be challenging for the compressed timeframe of HDR brachytherapy. A comparison to classical implant systems is fast but may no longer be relevant for the optimized dose distributions and modern treatments that can be achieved in HDR treatment planning. Our clinic has traditionally performed pre-treatment quality assurance based on an analytical relationship that predicts the total treatment time based on the volume receiving the prescription dose (V_{100}), the prescription dose, and the source strength.[2] However, our experience is that this analytical relationship cannot accurately predict the total treatment time for implants and treatment plans that deviate from our typical plans.

AIM

To investigate the utility of Mobius3D (Varian, Palo Alto, CA) for performing independent secondary dose calculations for a variety of HDR treatment plans

METHODS

For plan checks, Mobius3D performs a point dose comparison for any calculation point exported as part of the RTPLAN file (e.g., optimization or dose reporting points). Mobius3D calculates dose using TG-43 formalism for a point source (i.e., without anisotropy corrections). To investigate the differences between the primary treatment planning system (Elekta Oncentra) and Mobius3D for a Flexitron Ir-192 afterloader, comparisons were performed for a single dwell position and a variety of clinical cases, including interstitial implants, superficial planar custom applicators, GYN applicators, and strut-based and balloon-based breast applicators.

For a single dwell position, **Figure 1** illustrates the locations for which point dose comparisons were performed. For clinical plans, the location of calculation points was chosen using a variety of methods (both manual and automatic) available in Oncentra **(Figure 2).** For instance, for a vaginal cuff cylinder treatment, optimization points created as part of the planning process at the desired treatment depth along the length of the cylinder were used for Mobius3D vs. Oncentra comparison (**Figure 2a**). For other types of treatment plans, the "target points" functionality of Oncentra was used to place calculation points randomly distributed on the surface of a contour (e.g., the target contour as illustrated in **Figure 2d** for a custom scalp applicator).

RESULTS

SINGLE DWELL POSITION: Figure 1 shows the configuration of calculation points at various radial distances (2-50 mm) and polar angles for the single dwell position comparison. Due to the lack of anisotropy correction, the Mobius3D calculation disagreed with Oncentra by >10% for some calculation points, located close to the source or at angles of large anisotropy; these points of disagreement are indicated in **Figure 1**.

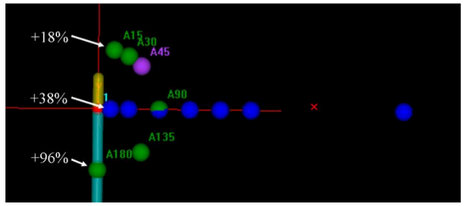

***Figure 1**: Calculation points used to compare Mobius3D vs. Oncentra for a single dwell position of the Flexitron Ir-192 source. The points with the largest discrepancy are indicated with arrows. The points that differ by +18% and +96% are located 1cm from the dwell position, while the point that differs by +38% is located 2mm from the dwell position.*

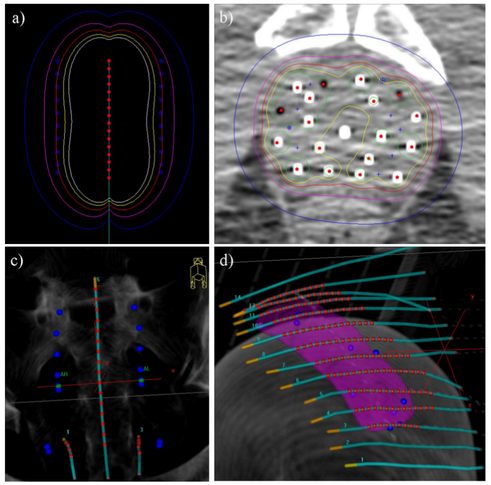

***Figure 2**: (a) Cylinder plan with calculation points (shown in blue) at the desired treatment depth along the desired treatment length, (b) an interstitial prostate implant with triangular basal calculation points (blue crosses), (c) tandem and ovoid plan with calculation points placed for optimization and dose reporting (Point A), and (d) custom applicator scalp plan with calculation points placed on the surface of the target structure (pink).*

***Table 1:** Summary of calculation point agreement (% differences are Mobius3D dose – Oncentra dose) for clinical cases.*

Treatment plan type	Type of calculation points	Number of points	Max % Difference	Median % Difference (std dev)
	GYN			
Cylinder	Optimization points (5 mm depth)	19	2.1	-1.9 (0.1)
Ovoids	Optimization points (surface and 5 mm depth)	8	3.4	-3.0 (0.3)
Tandem and Ovoids	Plan optimization points and Point A	16	2.3	-2.0 (0.2)
Tandem and Ring (T&R)	Plan optimization points and Point A	20	5.1	-0.3 (2.5)
T&R w/ interstitial needles	Target points* and Point A	22	4.5	-1.5 (1.7)
Interstitial Syed	Target points	10	4.3	-0.4 (1.8)
	Breast			
Contura Balloon	Target points**	20	4.7	-2.1 (2.7)
Interstitial	Target points	20	3.4	-0.1 (1.2)
SAVI	Target points**	20	4.8	-2.0 (2.0)
	Superficial planar implants			
Freiberg Flap for Chestwall	Target points	25	1.8	0.0 (0.7)
Custom Neck	Target points	40	3.0	-1.1 (1.0)
Custom Forehead	Target points	20	1.7	-0.9 (0.7)
Custom Neck & Shoulder	Target points	50	2.0	-0.3 (0.9)
Custom Scalp	Target points	10	2.7	-2.1 (0.6)
	Prostate			
Interstitial	Triangular basal dose points	73	3.6	-0.4 (1.0)

*Target points are placed on the surface of the target contour unless otherwise stated
**Target points placed on a surface created by expanding the balloon / SAVI applicator by 1cm

CLINICAL PLANS: Though differences >10% were observed for a single source position, the clinical plans summarized in **Table 1** generally showed agreement within 5%. Of the 373 points calculated, the difference between Mobius and Oncentra was >3% for 20 points (5.4%) and >5% for one point (0.3%). The point with >5% discrepancy was located on the ring surface (6mm from the source channel) for a tandem and ring plan.

However, if the location of calculation points is not chosen carefully, discrepancies > 5% can also be observed for clinical cases. For instance, for a calculation point placed near the stem of the balloon for a breast treatment plan, the dose difference was 13.0% (**Figure 3a**), and dose differences as high as 22.7% were found for points placed near catheter tips for a strut-based breast applicator (**Figure 3b**). Placement of calculation points on the surface of a contour created by expanding the applicator by 1cm was used to prevent calculation points from being too close to source dwell positions for our balloon-based and strut-based (SAVI) breast plan comparisons (**Figure 3c**).

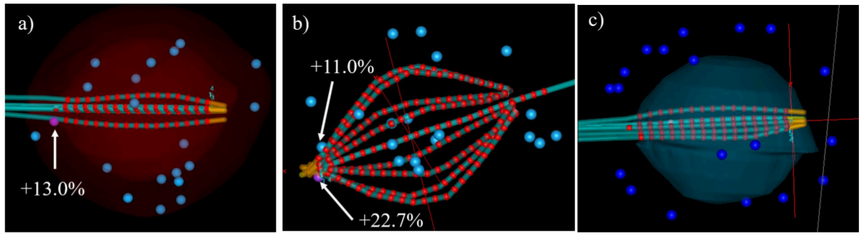

***Figure 3**: Calculation points (shown in blue) placed near the (a) stem of a breast balloon and (b) near the tips of catheters in a strut-based breast applicator that led to dose differences >5.0% between Oncentra and Mobius3D. For both (a) and (b), the calculation points were placed on the surface of the PTV_eval structure. However, for the same case as (a), if calculation points are placed on a contour created by expanding the balloon (shown in light blue) by 1cm, all calculation points agree within 5.0%.*

SUMMARY AND CONCLUSIONS

- Mobius3D dose calculations were performed automatically using RTPLAN files, and point dose comparisons against the primary treatment planning system (Oncentra) were performed at various locations for a single dwell position plan as well as a wide variety of clinical treatment plans.
- Mobius3D secondary dose calculations for HDR brachytherapy are fast and appropriate for a variety of implant techniques and applicators.
- Though Mobius3D uses a point source approximation and does not perform anisotropy corrections, results typically agree within 5% of a primary treatment planning system if dose comparison points are chosen to be in areas less affected by anisotropy. For instance points should be placed ≥1cm from dwell positions and not along the source path (e.g., not directly above the tip of an applicator) for best agreement.

REFERENCES

1. G.J. Kutcher, L. Coia, M. Gillin, et al. Comprehensive QA for radiation oncology: Report of AAPM Radiation Therapy committee Task Group 40. *Med Phys* 21(4). 581-618 (1994).

2. R.K. Das, K.A. Bradley, I.A. Nelson, R. Patel, and B.R. Thomadsen. Quality assurance of treatment plans for interstitial and intracavitary high-dose-rate brachytherapy. *Brachytherapy* 5(1), 56–60 (2006).

CONTACT INFORMATION

jyhuang4@wisc.edu