Independent Verification of VMAT Treatment Plans Using a DICOM-RT Framework

R. Reynolds, S. Stojadinovic, A. Pompos, X. Gu, R. Foster, T. Solberg
UT Southwestern Medical Center, Dallas, TX

Purpose/Objectives

To compare volumetric modulated arc therapy (VMAT) treatment plans calculated with Eclipse 10 (RapidArc, Varian Medical Systems) and Pinnacle 9.2 (SmartArc, Philips Healthcare) to those computed with an independent verification system utilizing a DICOM-RT framework Mobius3D (M3D 1.1, Mobius Medical Systems, LP) .

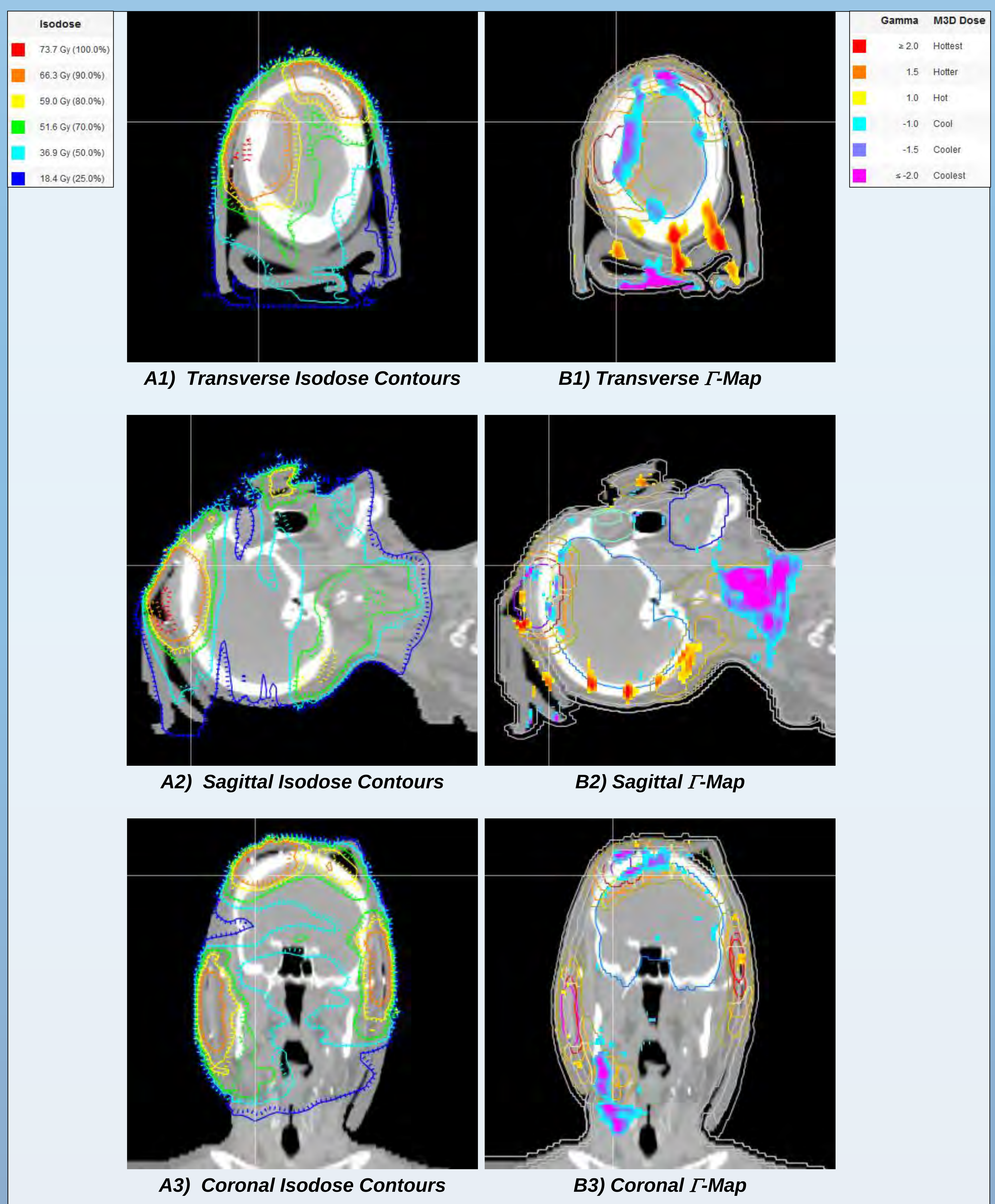

Figure 1. Plots of isodose contour lines (left side) and heat maps of 3D Γ-analysis (right side) are overlaid three orthogonal CT reconstructed planes intersecting at the planned isocenter. The solid isodose lines are calculated by the TPS and the dashed lines are by M3D.

Methods and Materials

Mobius3D (M3D) utilizes standardized machine data, supplemented by custom scaled measured depth dose curves, output factors and off-axis ratios, to create institution specific beam models as an independent dose validation check. A randomly selected set of clinical radiotherapy plans generated by two treatment planning systems (TPS) consisting of 26 RapidArc prostate plans and 29 SmartArc head and neck plans were exported to M3D. The requisite DICOM-RT files sent to M3D included CT images, contoured structure sets, RT plan and RT dose. This data was used to recalculate 3D dose distributions using a collapsed cone algorithm in M3D.

Dose distributions were compared to those calculated by the TPS 3D dose using a 3D Γ-analysis with 3% global dose difference and 3 mm isodose point distance criteria (Figure 1). Additionally, TPS's and M3D's target coverage and regions of interests sparing were compared by calculating the mean dose percent difference for each structure. DVH from each system were also compared (Figure 2).

Point dose measurements utilizing a 0.015cc pin-point ion chamber were conducted in a solid water slab phantom for all 55 plans. These measurements were compared to TPS calculated results for each plan mapped to the slab phantom. The phantom was always positioned such that the point of measurement was inside of the primary PTV for each plan.

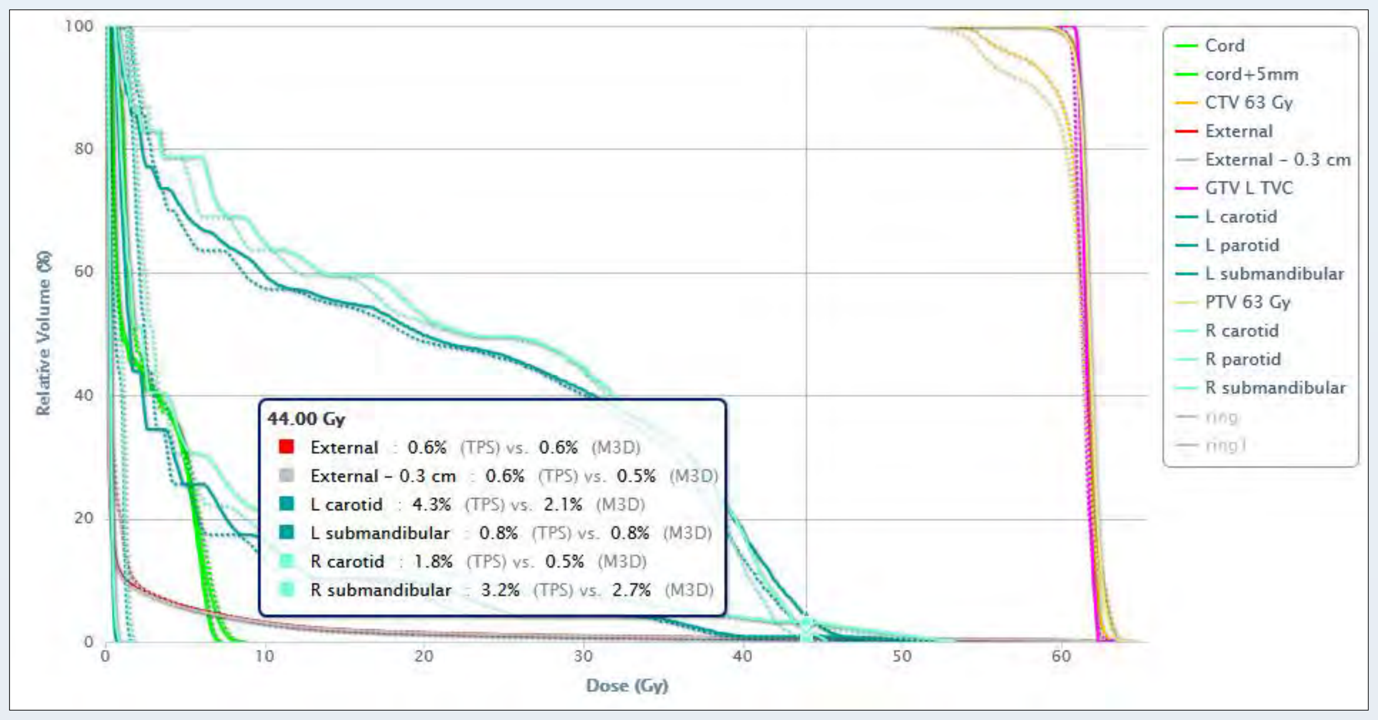

Figure 2. DVH comparisons between TPS (solid lines) and M3D (dashed lines). Results are shown for several TPS contoured regions of interest.

Results

On average, M3D plans showed excellent 3D Γ passing rates agreement as presented in Table 1. The percent difference between M3D and TPS calculated mean target dose for the primary PTV is also shown in Table 1, along with the percent difference between TPS and phantom based ion chamber measurements. For a larger number of volumetric regions of interest, 46 RapidArc and 44 SmartArc, differences between TPS and M3D demonstrated small differences of -0.3%±1.2% and -1.2%±0.9%, respectively.

	# Plans	M3D to TPS (% Diff.)	Measured to TPS (% Diff.)
RapidArc	26	-0.5%+1.1%	1.3% + 1.4%

	# Plans	M3D to TPS (% Diff.)	Measured to TPS (% Diff.)
SmartArc	29	-1.3%+1.0%	-0.9%+1.5%

M3D to TPS 3D Γ	RapidArc	SmartArc
	99.1%+1.1%	95.7%+2.2%

Table 1. Summary of results.

Conclusions

Mobius3D enables a paradigm shift in clinical quality assurance practice by moving beyond single point dose and MU verification to a full 3D treatment plan QA check. The VMAT results obtained utilizing fast and fully automated M3D software showed that M3D is suitable for an independent check of RapidArc and SmartArc plans.

The recently released Mobius3D 1.2 with MobiusFX has the ability to recompute the M3D dose calculations based on log files acquired from the linac during standard treatment delivery. This will allow for a full patient specific QA comparison of the delivered plan (DVH, 3D Γ, PTV Coverage, etc.) to the TPS.

This promises an automated system for not only independent plan checks but also patient specific QA measurements using a single system with a convenient web-based interface.

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