# One-Stop-Shop for End-To-End Patient-Specific QA: A Glimpse Into the Future

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## INTRODUCTION

LAP has recently developed a novel end-to-end solution for all Patient Specific QA in a single shop platform within RadCalc. In addition, a True Composite EPID based in vivo dosimetry solution which reconstructs the delivered volumetric dose on the patient's anatomy can be compared to the TPS intended dose. RadCalc also includes a full 3D secondary calculation using CC/MC and a pre-treatment solution for EPID based patient specific QA. Using anthropomorphic phantoms, we have simulated, planned, QA'd and treated intracranial SRS and SBRT lung. The results of our current clinical and QA workflows are to be compared to the solutions within RadCalc.

## BACKGROUND

The field is moving to more robust patient specific QA methods with recent recommendations from the AAPM's Task Groups 218 and 219(1,2,3). As recommended by the AAPM reports, secondary dose checks conducted in a volumetric 3D dose comparison are favorable. These recommendations also call for continued IMRT QA, preferably in a True Composite of the delivery right on the patient CT. As new vendor solutions emerge, we must ensure that they are properly validated before clinical implementation. Validation should be conducted against current clinical workflows to reduce systematic errors such as those introduced in MLC modeling parameters in Treatment Planning Systems and other dose computation systems. 3D second dose checks establish confidence in the results as well as highlight the clinical resources needed for implementation and normal clinical activities.(4)

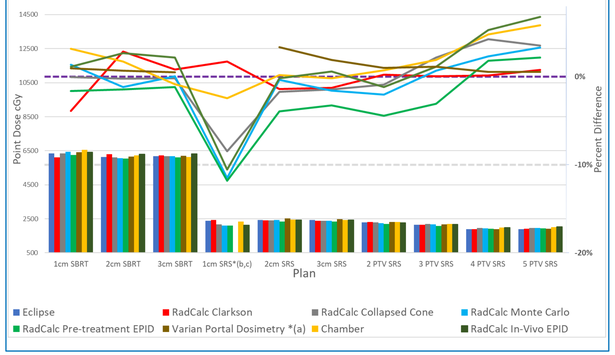
## MATERIALS AND METHODS

IMT's MaxHD anthropomorphic head phantom and the CIRS Dynamic Thorax phantom were simulated to mimic that of a patient SRS and Lung SBRT.
All plans were delivered for PSQA using current clinical workflow. RadCalc's pre-treatment QA dose volume reconstruction used the same measurements from the clinical workflow.
A pin-point ion chamber was inserted into the phantoms and the plans were delivered with the imager out. The same dosimetry imaging template was used from the pre-treatment measurements to provide a chamber comparison to RadCalc's EPID in vivo results.

## RESULTS

The new single shop solution by RadCalc has produced results in agreement with our existing secondary MU calculation and pre-treatment QA measurements.

Figure 1: End-to-End Chamber Dose Computed and Measured




## RESULTS CONTINUED

The individual modules of the novel end-to-end solution within RadCalc were evaluated separately. All treatment plans were computed with AcurosXB 15605 (Varian Medical Systems). All point dose measurements were performed using an Exradin A26 (Standard Imaging). **Figure 1** demonstrates an overview of the original results of the end-to-end chamber measurements compared to point dose. Two things to note are that the tested beam model is not commissioned for clinical SRS/SBRT treatments, therefore, a limitation in missing small field dosimetry was identified for the 1cm SRS case with the Varian Portal Dosimetry and all RadCalc 3D volumetric dose modules. However, the chamber dose demonstrated Acuros and the extrapolation in the RadCalc Clarkson method were both able to compute accurately. **Figure 2** demonstrates the percent difference of point doses from RadCalc Clarkson, RadCalc Collapsed Cone (CC), RadCalc Monte Carlo (MC) and chamber measurements all compared to the TPS dose. Good agreements are demonstrated overall. Of note are the tracking of RadCalc CC and MC with the chamber readings for the multi-target, single isocenter SRS treatment plans. **Figure 3** focuses on the agreement between RadCalc's Pre-Treatment QA against Varian Portal Dosimetry using the same clinical criteria of 2%/2mm and 10% Rx dose threshold. Additional benefits of the RadCalc Suite is demonstrated in the following images. **Image 1** demonstrates evaluation of gamma results (limited to PTVs as recommended in TG 218) on the patient's anatomy in 2D and 3D. **Image 2** illustrates RadCalc isodose line visualization of EPID dose volume overlayed on TPS dose volume. **Table 1** provides the Gamma passing rates for all plans at the TG 219 recommended criteria of 3% and 2mm with a dose threshold of 10%. Two things to note were the improved results after adding the 1cm OF for the 1cm SRS resulting in increased gamma passing rates from 97.3% to 98.1% for pre-treatment and 97.9% to 99.7%. For the 3cm SBRT case, both the angular and dose grid resolution had to be increased due to significant discrepancies in the field edges for the in-vivo results. **Figure 4** demonstrates the improvement of the RadCalc dose volume computation after fine tunning the machine model with the appropriate small field dosimetry data.

Figure 2 Point Dose % Difference Comparison

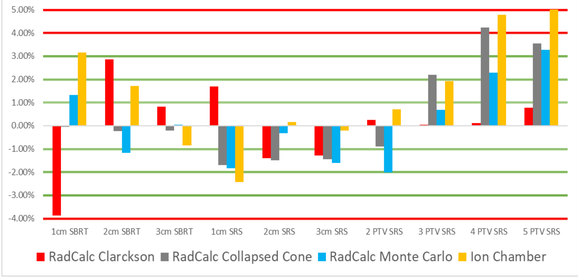



Figure 3 Pre-treatment Gamma and Max Dose Percent Difference

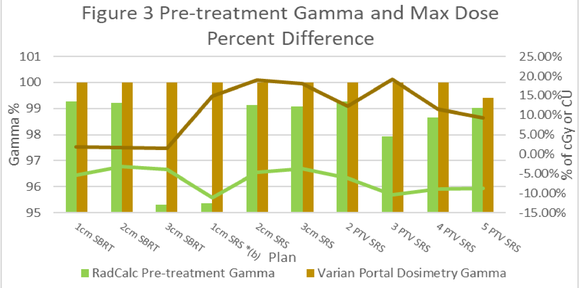



Image 1: RadCalc Gamma results visualized in 2D and 3D limited to the PTV volume

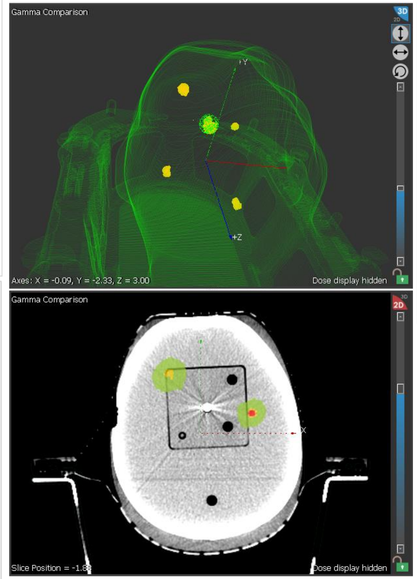
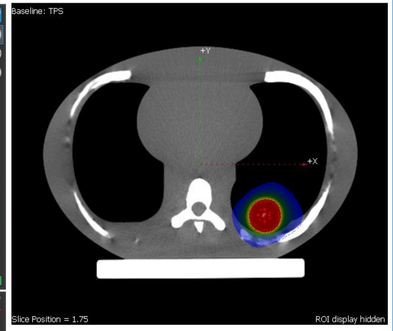



Image 2: RadCalc isodose line visualization of EPID dose overlayed on TPS dose



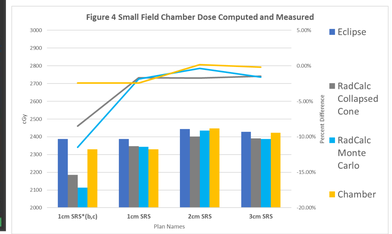




**Figure 1** **[b]Portal Dosimetry provides an average Calibrated Units (CU) value over the 2D area evaluated against the predicted dose. *[b]Portal Dosimetry was analyzed relatively in conjunction with the chamber dose value for the 1cm SRS plan. *[c]For RadCalc the corrected model with the appropriate 1cm data is demonstrated in **Figure 2** and **Figure 4**.

**Table 1: TG 219 Gamma Passing rate for each plan 3%/2mm 10% Dose Threshold**

| Plan | 1cm SBRT | 2cm SBRT | 3cm SBRT | *3cm SBRT | 1cm SRS | **1cm SRS | 2cm SRS | 3cm SRS | 2 PTV SRS | 3 PTV SRS | 4 PTV SRS | 5 PTV SRS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RadCalc Collapsed Cone Gamma | 99.59 | 99.66 | 98.97 | 98.97 | 33.67 | 99.99 | 99.98 | 99.91 | 99.77 | 99.55 | 99.77 | 99.80 |
| RadCalc Monte Carlo Gamma | 99.79 | 99.71 | 99.74 | 99.74 | 100.00 | 100.00 | 99.89 | 99.93 | 99.48 | 99.14 | 99.34 | 99.58 |
| RadCalc Pre-Treatment Gamma | 99.38 | 99.44 | 97.27 | 99.30 | 98.81 | 98.81 | 99.39 | 99.46 | 99.42 | 98.88 | 99.27 | 99.45 |
| RadCalc In-Vivo Gamma | 99.76 | 99.43 | 97.93 | 99.65 | 99.31 | 99.31 | 99.90 | 99.89 | 99.43 | 98.08 | 97.90 | 98.63 |

**Original 4 degree angular resolution and 3mm dose grid recomputed with 3 degree angular resolution and 2mm dose grid*
*** Original 1cm beam data was missing in RadCalc, this was extrapolated from point dose module and checked with Acuros results.*

## CONCLUSIONS

The benefits of using a suite like RadCalc extend beyond the convenience of a single integrated solution. As per recommendation from AAPM TG-219, a full 3D secondary MU calculation is more robust than a single calc point and allows you to view the isodose lines in 3D. The 3D QA and in vivo solution utilizing EPID dosimetry exceed traditional OSLD or diode readings by demonstrating what was truly delivered on your 3D data set. The full end-to-end patient-specific QA solution offered by RadCalc provides confidence that the patient will receive their treatment as intended.

## REFERENCES

1. Glenn et al, *Photon beam modeling variations predict errors in IMRT dosimetry audits.* Radiotherapy & Oncology 166(2022)8-14
2. Miften et al, *Tolerance limits and methodologies for IMRT measurement-based verificationQA: Recommendations of AAPM Task Group No. 218.* Med. Phys. 45 (4), April 2018
3. Zhu et al, *Report of AAPM Task Group 219 on independent calculation-based dose/MU verification for IMRT*. Medical Physics. 2021;48:e808–e829.
4. Kim et al, *Commissioning and clinical implementation of Mobius3D and MobiusFX: Experience on multiple linear accelerators*. Physica Medica 80 (2020) 1–9

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## CONTACT INFORMATION

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