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Commissioning Of A Novel, Automated Offline Adaptive Radiotherapy Assessment Software

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INTRODUCTION

Adaptive radiotherapy (ART) has been shown to provide significant dosimetric benefits to patients. Changes in patient anatomy, daily setup, and dose distribution can necessitate plan modifications to improve plan quality and patient outcomes. However, adaptive workflows are resource and time intensive, requiring significant dosimetrist, physicist, and physician input to assess the necessity of adapting the current treatment plan.

ChartCheck Adaptive, a novel, offline ART software recently released by Radformation, provides clinicians with quantitative insights through an automated workflow. The software utilizes daily imaging to generate synthetic CT data sets, allowing for Monte Carlo dose re-calculation and summation over the entire treatment course. Daily dose maps and DVH metrics are compared to those achieved by the original treatment plan, and notifications are generated when thresholds are exceeded. This results in a day-to-day break-down of dose accumulation to inform patient-specific replanning decisions, rather than relying on pre-determined treatment plan adaptation schedules, some of which can be subjective and can vary amongst clinicians.

PURPOSE

Before releasing the system to our clinic, we set out to commission ChartCheck Adaptive for clinical use. We developed a series of phantom studies to test the software's ability to generate accurate synthetic CT scans, perform dose calculation, and track DVH metrics on both solid water and anthropomorphic phantoms.

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METHOD

Two sets of phantom studies were performed to test ChartCheck Adaptive on static and changing anatomy.

VMAT plans were generated to deliver TG-119-based prostate and C-shape plans on solid water (**Figure 1**).

- 30x30 cm^2 slabs of solid water 20cm thick

An anthropomorphic head and neck RANDO phantom (Radiology Support Devices, Inc.) was used to generate VMAT plans of a unilateral neck treatment. A tissue-equivalent putty was added to the neck, with adjustments made prior to first fraction to test how the system assesses changes in anatomy. **Figure 2** shows the synthetic CT for both static and deformed targets:

- Fractions 1-5: no change in putty
- Fractions 6-10: volume of putty was kept constant; tape was used to reshape the putty the putty, pulling the putty closer to the phantom in the anterior and posterior portions.

Treatment data was automatically imported by ChartCheck to perform synthetic CT generation and MonteCarlo dose calculation. Results were compared to Acuros XB calculations in Eclipse (Varian Medical Systems). ChartCheck calculates DVH curves and shows the comparison between the delivered and the initial plan (**Figure 3**).

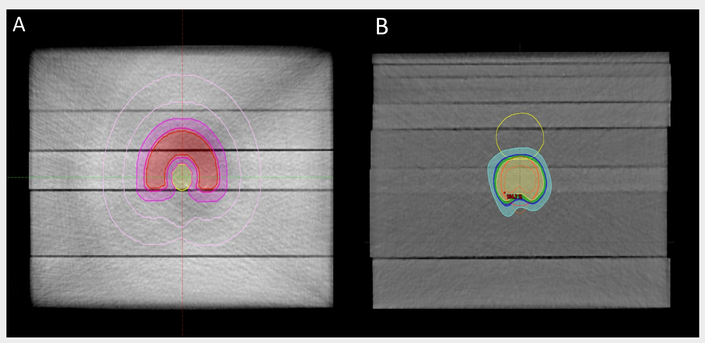

Figure 1. Solid water slabs at 20cm thick. A) C-shaped target volumes and B) Mock Prostate Plan based on TG-119.

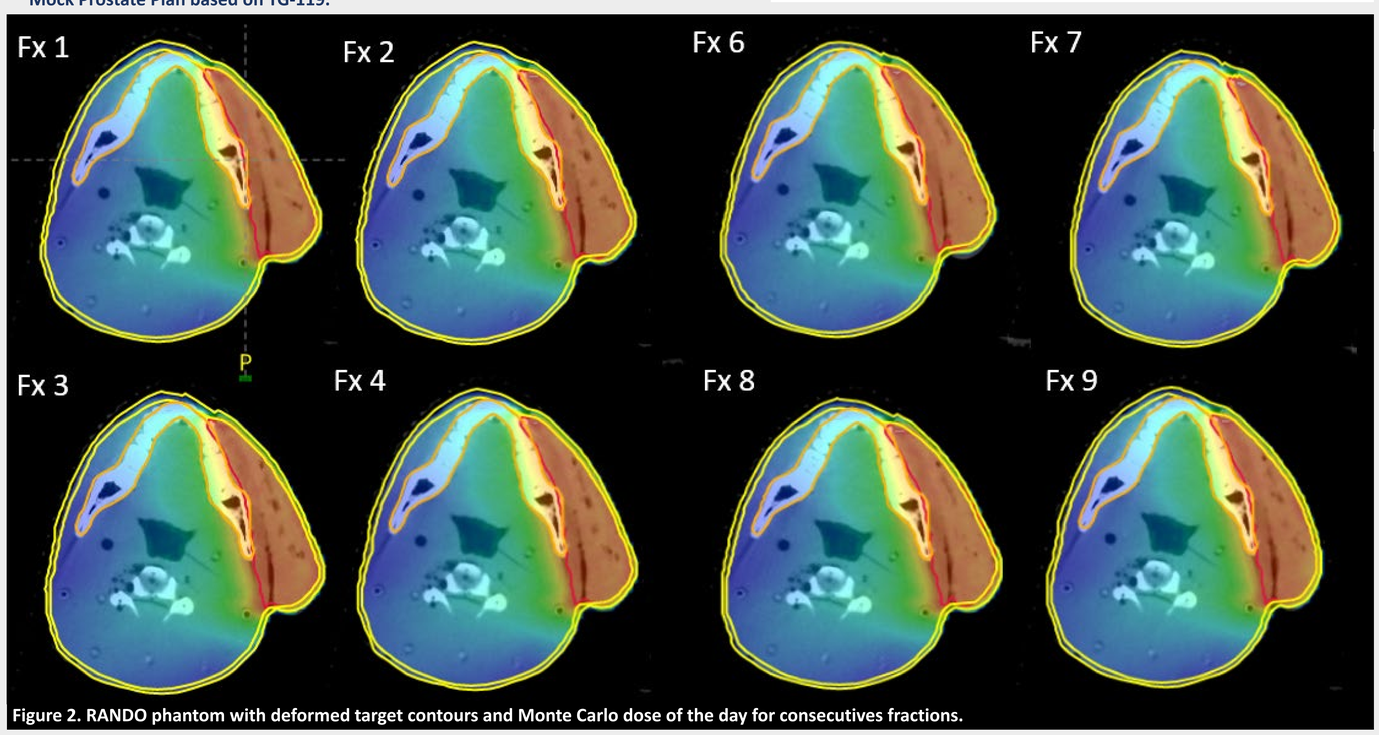

Figure 2. RANDO phantom with deformed target contours and Monte Carlo dose of the day for consecutives fractions.

RESULTS

PTV D95% matched within 0.6% for PTV_Prostate and PTV_Core across each delivered fraction when comparing Acuros and RadMonteCarlo.

For the head and neck plan, ChartCheck constraint analysis signaled a small loss of coverage to the PTV D95%. The average for the first 5 fractions was 99.04±0.01% and for fraction 6-10 was of 98.18±0.01%.

Figure 2 shows the synthetic CT from various fraction from the CBCT images taken of that same fraction with dose of the day and deformed target contours.

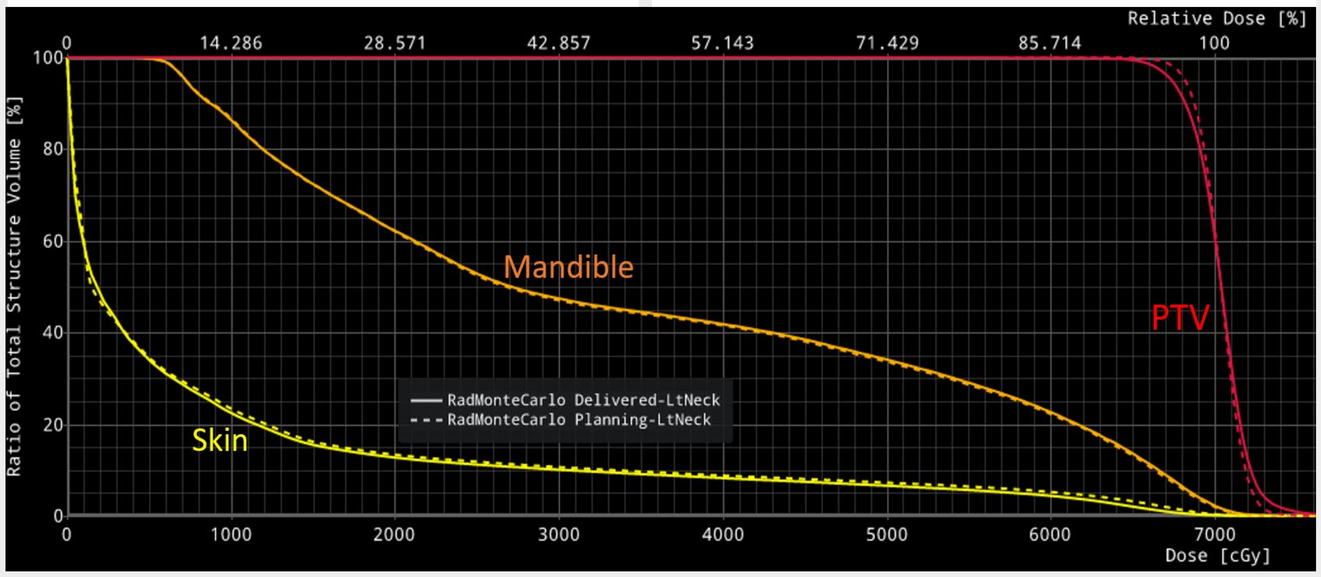

Figure 3. Visual of ChartCheck Adaptive DVH for a fraction comparing the RadMonteCarlo calculation of the initial planned vs of the delivered plan for fraction 7.

Fraction 1-5

- PTV V95% remained within 1.6 % of initial value and GTV volume remains within 2%. (**Figures 4 and 5**)

Fraction 6-10

- PTV DVH dropped compared to planned.
- GTV volume drops of 4.9% on fraction 6 and return to a max drop of 2.4% in the remaining fractions.

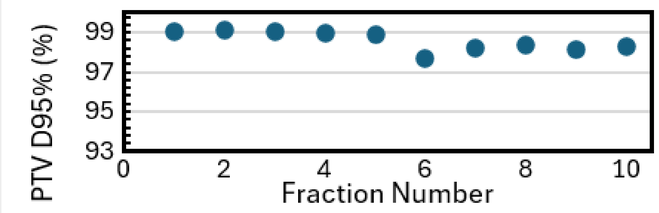

Figure 4. PTV V95% variation from initial calculation with RadMonteCarlo.

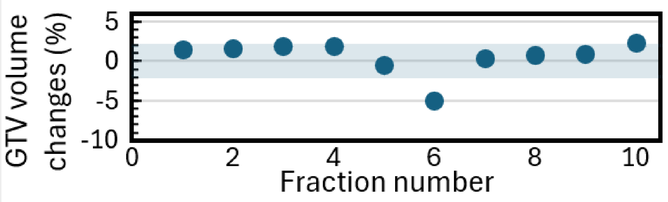

Figure 5. GTV volume changes for RANDO phantom. Shaded area from ±2%.

ChartCheck Adaptive can help clinicians verify that observed changes in dose coverage are associated with anatomical changes. The DVH calculation for all OARs is also a useful tool to view the changes requiring a replan.

DISCUSSION

The results demonstrate that ChartCheck provides accurate dose calculations in geometrically stable treatment scenarios. For the prostate and C-shape phantom plans, it accurately generated synthetic CTs and calculated dose on solid water.

The small deformation in Fx 6 introduce an outlier in the GTV volume calculation, but the software stabilized again in following fractions. This drop in the calculated GTV volume can be used as visual guide, directing attention to the areas that warrant closer evaluation for meaningful anatomical changes that may justify and benefit from replanning.

CONCLUSIONS

ChartCheck Adaptive generated synthetic CTs from daily imaging, yielding accurate representations of dose accumulation per fraction for two separate phantom studies. We believe that ChartCheck Adaptive can be clinically advantageous in performing offline ART through in-vivo dose tracking.