Scratching the (dose) surface: demonstrating the power and potential of dose- surface maps to investigate spatial effects of treatment planning parameters on delivered dose to the rectum

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INTRODUCTION

- Delivered dose to the rectum is not always equivalent to planned dose during prostate RT.
- Spatial dose variations have been found to be predictive of several rectal toxicities [1,2,3].
- *However,* traditional DVH-based analysis lacks the spatial information required.
- Dose-surface maps (DSMs) are an emerging alternative to DVHs that preserve spatial information about dose to an organ's surface.

AIM

To use DSMs to evaluate the influence of treatment parameters on the level of spatial agreement between planned and delivered dose to the rectum.

METHODS

Study Cohorts

Three patient cohorts were prepared:
1) 20 patients prescribed 60 Gy/20 fr to a 7 mm PTV,
2) 20 patients prescribed 36.25 Gy/5 fr to a 5 mm PTV,
3) Group (1) replanned to have 5 mm margins.

Dose Surface Maps

DSMs were calculated using the workflow in **Figure 1** for each patient's plan and daily treatment fractions. Daily DSMs were aligned and summed together to calculate DSMs of delivered dose. Positions of the posterior and anterior rectal walls were also calculated at this time to track changes in rectum shape.

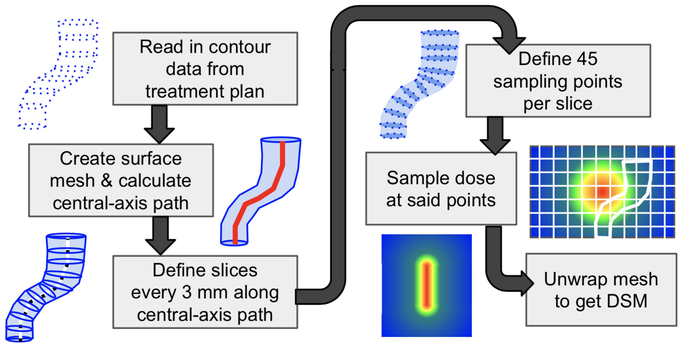

Figure 1: Dose-surface map (DSM) calculation workflow.

Analysis

Differences between planned and delivered DSMs were evaluated using paired permutation testing. Rectal wall motion between treatment and delivery was assessed with Wilcoxon rank-sum testing.

RESULTS

Effect of Margin Size

Significant differences between planned and delivered dose were observed for the 7 mm PTV and 5 mm PTV 20 fraction plans (**Fig 2a-d**). In both cases, a similar region of the posterior rectal wall received less dose than had been planned, suggesting PTV margin size does not significantly influence the degree to which planned and delivered rectum doses differ.

Effect of Fractionation Scheme

No significant differences between planned and delivered dose were observed for the 5 fraction plans, but were observed for the 20 fraction plans (**Fig 2**). Maximum mean dose differences were also smaller for the 5 fraction treatment (8% of presc. dose) than the 20 fraction ones (16% of presc. dose), which could indicate that set-up and motion uncertainties were larger in the longer treatment.

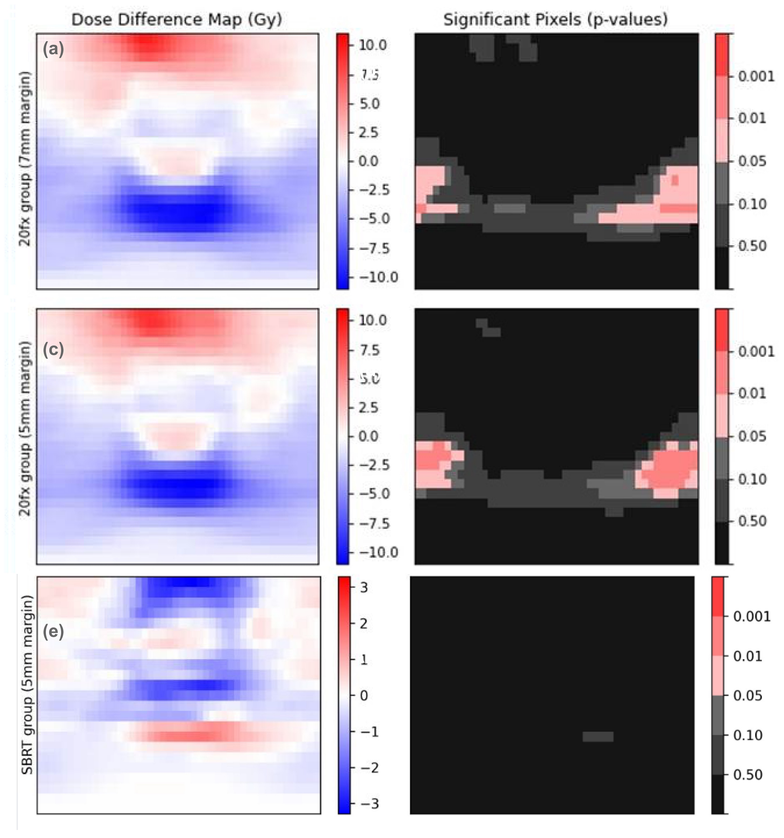

Figure 2: (Left) Mean dose difference maps between planned and delivered DSMs for the three patient cohorts (units of Gy). (Right) Maps of pixels found to differ significantly between planned and delivered DSMs. Colorbars indicate p-value ranges.

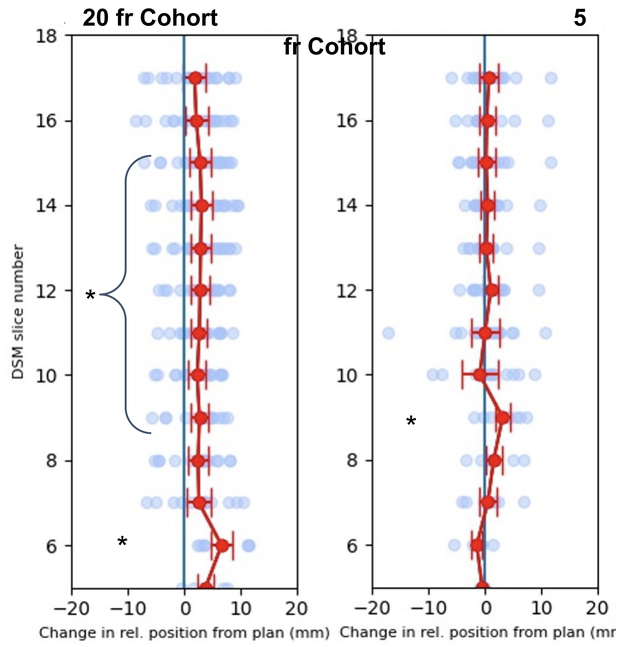

Figure 3: Change in sagittal offset of the posterior rectal wall from the PTV margin between plan and delivery. Mean positions and their 95% confidence intervals are shown in red, and individual patient data points shown in pale blue. Significant shifts between plan and delivery are indicated with asterisks.

Positional Shifting of the Rectal Wall

Change in rectal wall position was assessed by comparing the sagittal distances from the prostate PTV to the anterior or posterior rectal walls between planning and treatment delivery (**Fig 3**). A significant posterior shift was observed for the posterior rectal walls of patients in the 20 fraction groups. No significant positional shifts were observed for the 5 fraction group or the anterior walls. The significant positional shifts of the 20 fraction cohort occurred at the same level that the dose differences did, providing a possible explanation for the observed decreased delivered dose.

CONCLUSIONS

Significant dose differences between treatment plans and delivery and their underlying cause were identified using DSMs.

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