Leveraging high-fidelity planning for improved online adaptive stereotactic partial breast treatment efficacy

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INTRODUCTION/AIM

Introduction: Cone-beam computed tomography (CBCT)-guided online adaptive radiation therapy (OART) for stereotactic accelerated partial breast irradiation (APBI) **[1, 2]** can help mitigate the effects of inter-fraction lumpectomy bed variation **[3, 4]**. However, OART leads to a prolonged treatment time due to daily re-optimization of the treatment plan **[5]**, potentially increasing patient discomfort and intra-fraction variation **[6]**.

Aim: Investigate feasibility of utilizing high-fidelity (HF) mode to improve APBI OART efficacy.

METHOD

- Retrospective in-silico IRB-approved study included 25 patient datasets
- 10 training patients: iterative tuning of a high-fidelity planning strategy
- Remaining 15 patients: 5 OART treatment fractions emulated with/without HF
- Analysis of 300 validation cohort plans, including non-adaptive/adaptive plans
- Dose-volume-histogram (DVH) metrics, optimization times, and patient-specific-quality-assurance (PSQA) results compared with/without HF

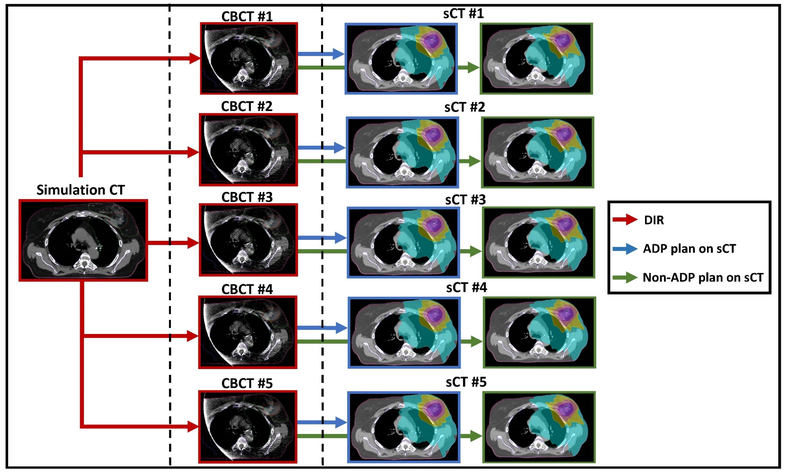
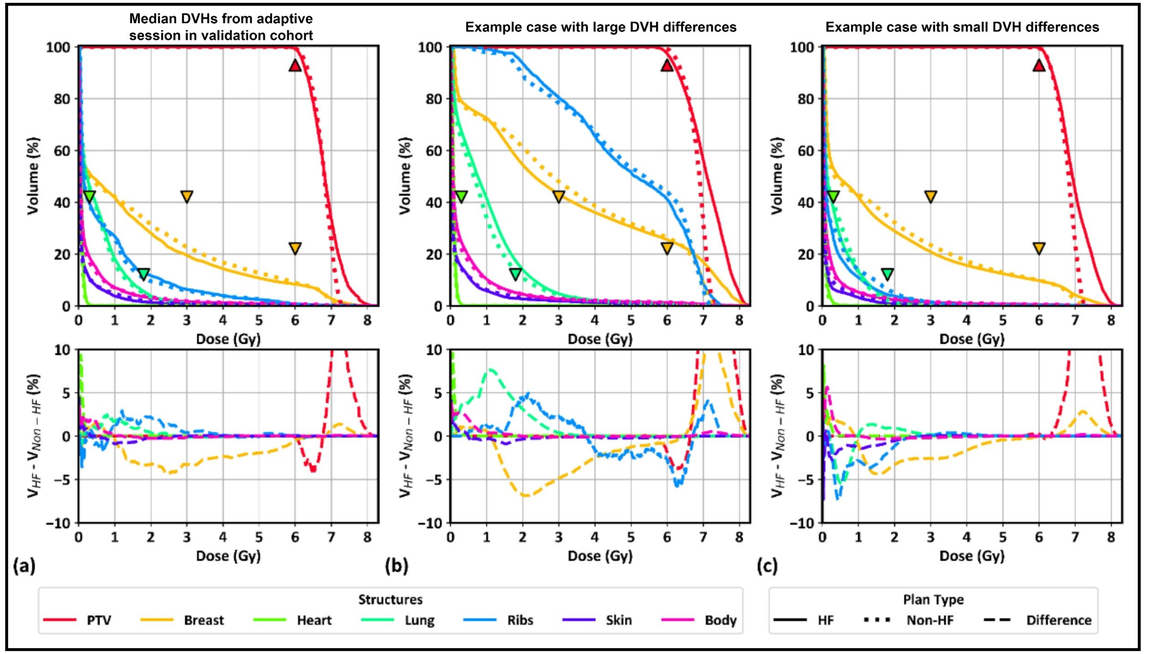


Figure 1. Study workflow. All normal tissue and gross tumor volumes were auto-contoured on daily CBCT images via Ethos v2.0 deep-learning algorithms and structure-guided deformable image registrations, respectively. Daily synthetic CT (sCT) images were generated via image-guided deformable image registrations (DIR) of the sim CT and daily CBCTs, which were utilized with the planning template and daily contours for adaptive plan optimization and non-adaptive plan recalculation. This process was repeated for 15 patients using both planning approaches (HF and Non-HF).

RESULTS

Figure 2. Median per-session dose volume histograms (DVH) for the entire adpative plan cohort (a) and a patient exhibiting larger (b) and smaller (c) differences between HF and Non-HF mode. HF (solid) and Non-HF (dotted) DVHs are illustrated in the top row while the relative volume differences (HF – Non-HF, dashed) are illustrated in the bottom row. Planning goals are illustrated by triangle tips.



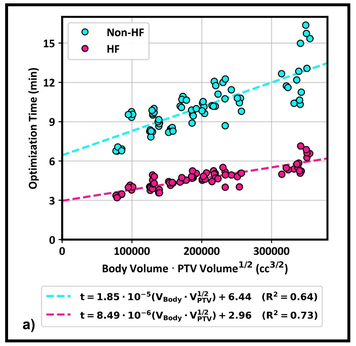


Figure 3. Adaptive plan optimization time as a function of body/PTV volume and plan type. Equations of best fit and R^2 are illustrated for each plan type.

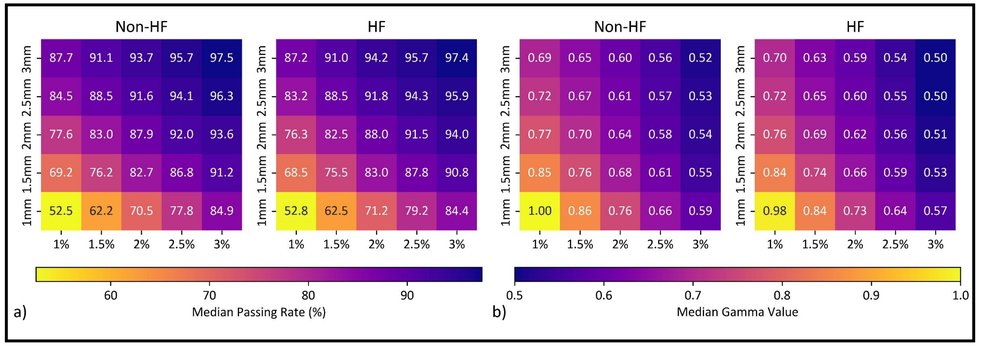


Figure 4. Heatmaps of median passing rate (a) and gamma value (b) obtained using a 10% minimum threshold and gamma threshold of 1. Twenty plans (10 non-adaptive, 10 adaptive) were measured with an ArcCHECK cylindrical diode array (Sun Nuclear, Melbourne, FL) for both plan types (HF and Non-HF) using the same patients and adaptive session number.

CONCLUSIONS

1. This work demonstrates that leveraging Ethos v2.0 HF mode may significantly improve stereotactic OART treatment efficiency for VMAT APBI.
2. Over 50% reduction in optimization time observed while maintaining plan quality, using a non-clinical system.
3. Results suggest potentially reduced patient discomfort and mitigated intra-fraction variations with HF planning.
4. First study, to authors' knowledge, investigating effects of HF on 1) SBRT plan quality and 2) OART workflow efficiency.

REFERENCES

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