Robustness of three treatment techniques against inter-fractional positional variations of the metal port in breast tissue expanders

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INTRODUCTION

- The most common tissue expander used in postmastectomy immediate breast reconstruction contains a metal port made of a rare earth magnet that is localized externally and is used as an injection site.
- For patients receiving postmastectomy radiation therapy, the metal port is in the field of radiation.[1-3]
- Perturbations in the dose distribution occur if the presence and location of the metal port is not accurately modelled in the treatment planning system.

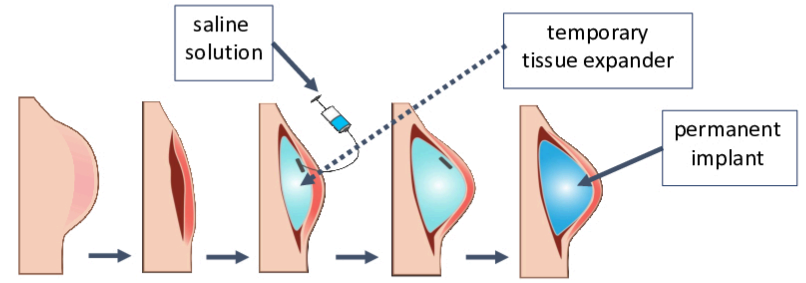

Figure 1: schematic diagram of postmastectomy expander-implant reconstruction.

OBJECTIVES

- To quantify and compare the robustness of the three most-common techniques for breast treatment against inter-fractional positional variation of the metal port in breast tissue expanders.
  - ➢ tangential 3DCRT, VMAT and helical Tomotherapy.
- Inform appropriate planning strategies for better robustness of radiation delivery in the presence of positional variations of the metal port.

METHODS

- 8 breast cases – treated originally on Tomotherapy .
- Daily acquired MVCT was compared with reference CT.
- Daily change in the position of the metal port were measured in the three cardinal directions.

- Immobilization and positioning of patients for breast treatments is identical in tangential 3DCRT, VMAT and helical Tomotherapy.
  - ➢ Measured errors were assumed to apply to all treatment techniques.
- A clinical plan of each technique was created for all patients in addition to the existing helical Tomotherapy plans.

For each treatment technique, two classes of error were modelled:

1. **Internal Port Error** (IPE) – port positional error relative to internal anatomy.
   - Directly edit voxel values in the CT dataset and artificially shift the metal port by measured error.
2. **Patient Registration Error** (PRE) – displacement of the whole patient relative to the treatment beam.
   - Displace the CT dataset wrt the original photon fluence by the measured error.

- For both classes of error, the effect of **daily variable** and **systematic** errors were evaluated.
- For a clinically meaningful dose analysis, a Region of Interest (ROI) was defined as a 5 mm expansion around the temporary implant within the PTV.

RESULTS: 1. Distribution of port positional error

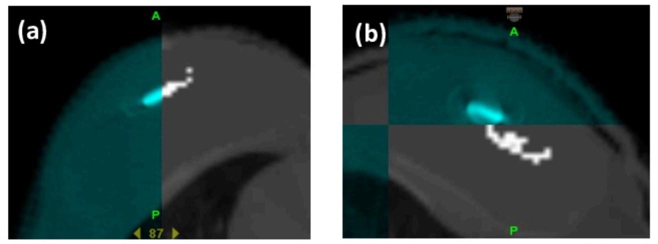

Figure 2: Checkered view of an MVCT image in the treatment position (turquoise) superimposed on the reference CT (gray) for two fractions. In (a) the metal port matches its original position and in (b) the metal port is displaced from its original position.

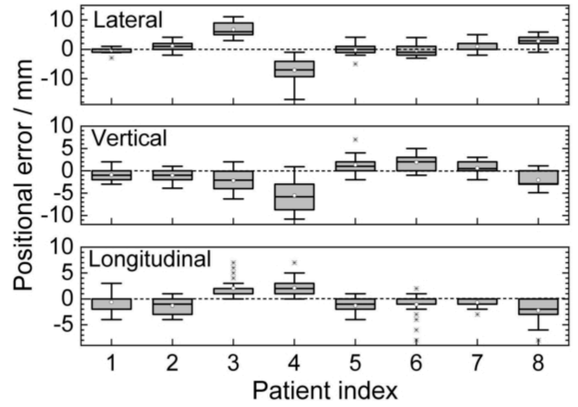

Figure 3: Box plot of inter-fractional positional error of the metal port per patient in the three cardinal directions.

RESULTS: 2. Dosimetric comparison

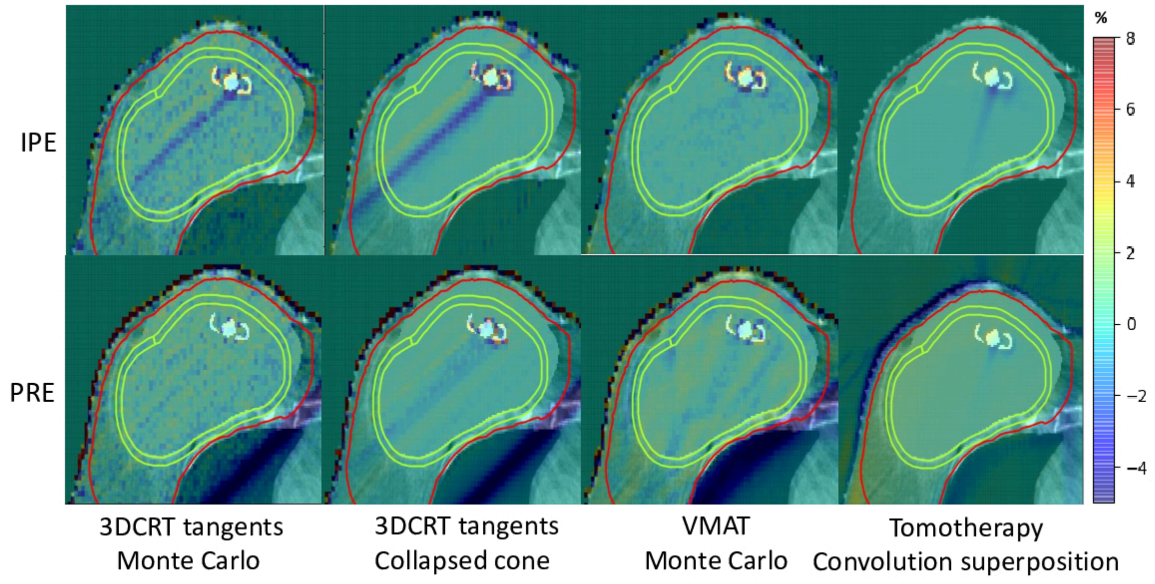

Figure 4: Percent dose difference maps for a representative patient when daily variable IPE and PRE are present. The red contour is the PTV. The area enclosed in the green contour is the ROI defined as a 5 mm expansion around the temporary implant. The percent dose differences are normalized to the prescription dose.

RESULTS: 3. Change in target coverage

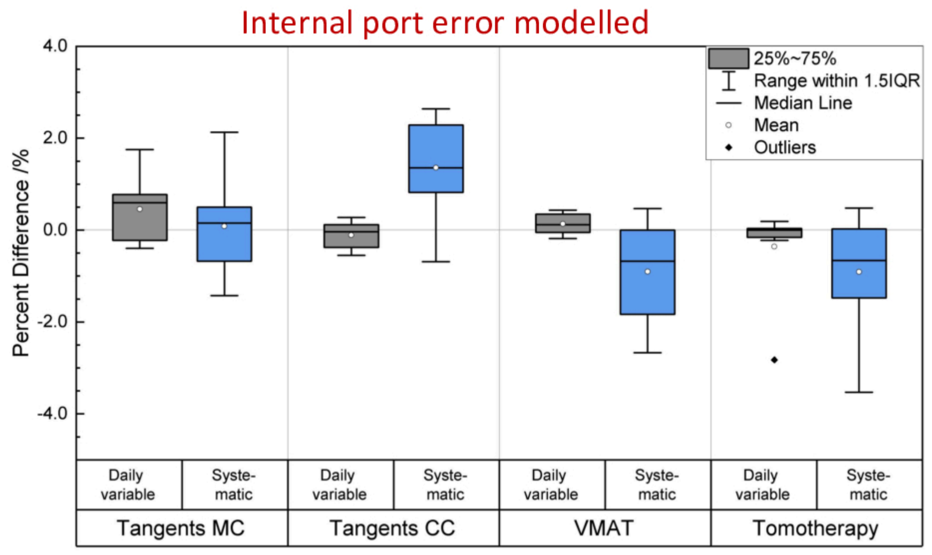

Figure 5: Change in $V_{100\%Rx}$ in the ROI when daily variable (gray) and systematic (blue) internal port positional errors are present in the different treatment techniques. MC – Monte Carlo. CC – Collapsed Cone.

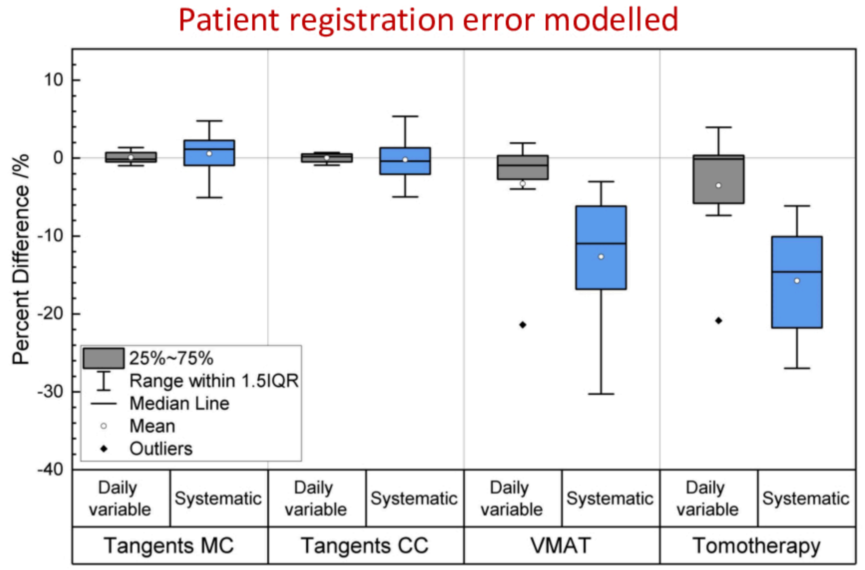

Figure 6: Change in $V_{100\%Rx}$ in the ROI when daily variable (gray) and systematic (blue) patient registration errors are present in the different treatment techniques. MC – Monte Carlo. CC – Collapsed Cone.

CONCLUSIONS

- Inter-fractional positional variations of metal port are generally small but can be up to 17 mm.
- Caused by a combination of IPE and PRE.
- PRE has larger dosimetric effect in target coverage.
- For daily variable port misalignment, plans with different modalities are clinically robust.
- For larger inter-fractional error:
  - VMAT and Tomotherapy are more robust against IPE.
  - Tangential 3DCRT treatment more robust against PRE.

- Overall alignment of anatomical landmarks should be prioritized over exact port match.
- Contouring the metal port with some uncertainty is acceptable.

REFERENCES

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