Evaluation of Feasibility of TrueBeam HyperSight Imaging for Adaptive Treatment Planning for Breast Patients

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ABSTRACT

Purpose: HyperSight CBCT (HS-CBCT) incorporates advanced iterative reconstruction algorithms (iCBCT and iCBCT-MAR), which may improve image quality and enable CBCT-based dose calculations. This study evaluated the dosimetric accuracy of HS-CBCT compared with CT simulation images in breast cancer patients.

Methods: Ten breast cancer patients from a prospective clinical trial (NCT06681233) were included. HS-CBCT images were acquired using two imaging protocols and reconstructed using standard and advanced algorithms. Treatment plans and structures from CT simulation were transferred to HS-CBCT datasets, and DVH metrics for target volumes and organs at risk were compared

Results: Compared with CT-sim HS-CBCT demonstrated small deviations in mean heart dose and PTV D95.

Conclusion: HS-CBCT demonstrated feasible dose calculation accuracy for breast radiotherapy .These findings support the potential use of HS-CBCT in adaptive radiotherapy workflows

DISCLOSURE

This research included a prospective imaging clinical trial (NCT06681233) supported by Varian Medical Systems/Siemens Healthineers

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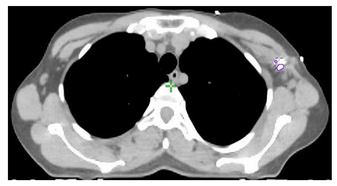
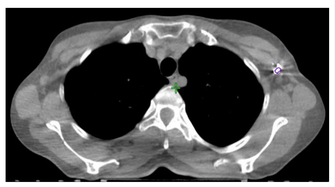
INTRODUCTION

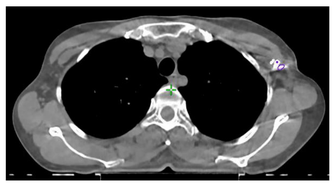
- CT Simulation **(CT-sim)** provides accurate HU values for treatment planning, whereas **standard CBCT** has limited dosimetric utility because of scatter related to its cone-beam geometry[1].
- Anatomical changes during breast radiotherapy may require replanning, and **HS-CBCT** with **iCBCT** and **iCBCT-MAR** may facilitate adaptive radiotherapy by improving image quality and HU accuracy for dose calculation.
- This study evaluates the dose calculation accuracy of **HS-CBCT** by comparing the dosimetric difference with **CT-sim** for breast cancer patients.

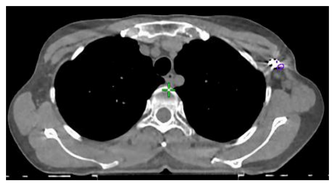
METHODS AND MATERIALS

- Ten breast patients were evaluated as part of a larger prospective clinical trial comparing **CT-sim** images with **standard CBCT (SCBCT)** and **HS-CBCT** images.


CT-Sim


Standard CBCT


HS-CBCT A


HS-CBCT B

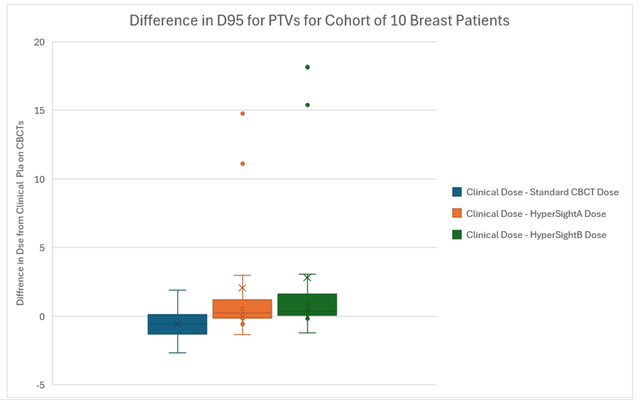
- Four patients were treated using breath-hold techniques, four were treated in the prone position, and two patients had breast expanders.
- HS-CBCT images were acquired using two different 125 kV protocols with 1.2 mAs for **HS-A** or 0.3 mAs for **HS-B**. Both protocols were used to evaluate the effect of different acquisition protocols on CBCT- based dose calculations.
- **HS-CBCT** were reconstructed using standard FDK, iCBCT, or **iCBCT-MAR** algorithms.
- Data analysis process map:

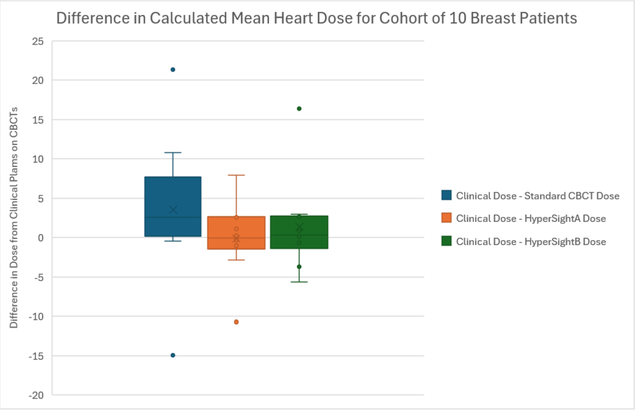
Image Rigid Registration: registered CT-Sim with CBCT and HS-CBCTs
↓
Structure set and RT plan transfer: CT-Sim to CBCT and HS-CBCTs
↓
Dose calculation: recalculated dose on CBCT and HS-CBCTs
↓
DVH Extraction: D_{95} of PTV and D_{mean} of OARs
↓
Statistical Analysis: $D_{difference} = D_{CT\_sim} - D_{CBCT}$

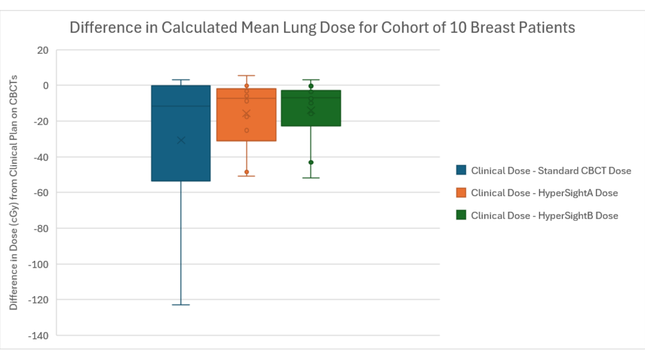
RESULTS

Metric	$D_{95}(\%)$	$Heart\ D_{mean}(cGy)$	$Lung\ D_{mean}(cGy)$
Standard CBCT	−0.57 ± 1.29 (p =0.54)	3.55 ± 9.17 (p=0.32)	−30.65 ± 46.56 (p=0.07)
HS-A	2.06 ± 4.75 (p=0.11)	-0.12 ± 4.76 (p=0.68)	−15.68 ± 19.91 (p = 0.03)
HS-B	2.82 ± 6.01 (p=0.10)	1.37 ± 5.89 (p=0.74)	−13.89 ± 18.59 (p = 0.04)

Table 1: Dosimetric differences between CT-sim and CBCT images, calculated as ($D_{CT\_sim} - D_{CBCT}$). Values are reported as average ± standard deviation with p-values from two-tailed paired t-tests for PTV D_{95}, mean lung and heart doses. HS-A and HS-B: HyperSight CBCT acquired using protocol A and B respectively.



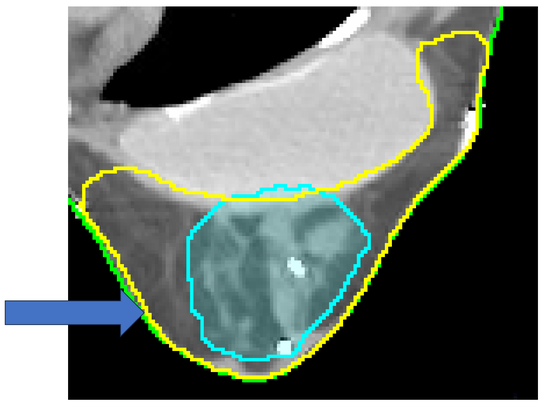


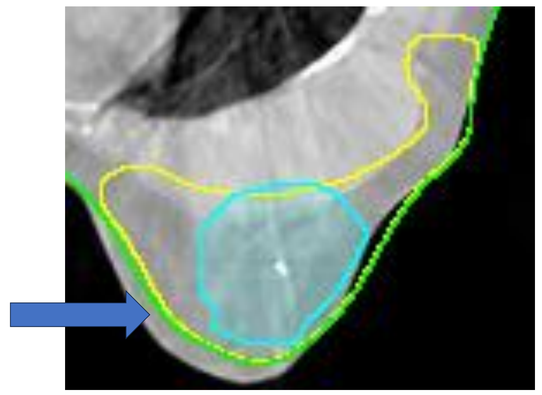


- Both HS protocols provided more accurate dosimetric representations D_{mean} of Heart with greatest improvements using the HS-CBCT A protocol
- Both HS protocols provided more accurate dosimetric representation D_{mean} of Lung with greatest improvements using the HS-CBCT B protocol.
- Paired t-test showed no significant statistical differences in PTV $\boldsymbol{D_{95}}$ or mean heart dose ($p > 0.05$). Mean lung dose showed statistical difference ($p < 0.05$) for HS-A and HS-B compared to the original CT used for treatment planning.

DISCUSSION

- **iCBCT-MAR** improved HU accuracy and reduced image artifacts, which may have contributed to the observed **reduction in dose calculation discrepancies** for patients with metal implants
- The dosimetric difference in **PTV** $\boldsymbol{D_{95}}$ across **HS-CBCT** may be due to **differences in external body contour**.
- Differences in body contour between CT-sim and HS-CBCT may have **altered depth of dose calculation** and contributed to **dose variability**[2].


CT-Sim


HS-CBCT B

CONCLUSIONS

- **iCBCT-MAR** resulting in more accurate dose calculations for OARs evaluated than standard CBCT while retaining accuracy for target volume evaluation.
- **HS-CBCT** demonstrated feasibility for dose calculation in our small cohort of breast patients for this evaluation.
- The ability to perform dose calculations directly on HS-CBCT images may facilitate **adaptive radiotherapy workflows**.

REFERENCES

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