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Contrast-Enhanced Cone Beam CT Capabilities of Halcyon with HyperSight

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ABSTRACT

Dynamic contrast enhanced CT (DCE-CT) is a functional imaging method for measuring vascular perfusion with high resolution and clinical value. DCE- cone beam CT (CBCT) has previously been prevented by low image quality and lengthy acquisition, however, enhanced image quality and rapid scan times of imaging solution HyperSight equipped onto radiation machines (Halcyon or TrueBeam) offers a solution. This approach provides the potential for CBCT-based functional measurements during routine treatment workflows.

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INTRODUCTION

- 50% of cancer patients require radiotherapy, highlighting the need to optimize treatment workflows
- **IGRT** relies largely on static anatomical imaging and remains time- and resource-intensive
- Extracting functional information from **CBCT** would permit biology-guided adaptive radiotherapy
- **DCE-CT**, a functional imaging technique, has not been integrated with **IGRT** due to limitations in **CBCT**

Research Question

Can Halcyon with HyperSight, featuring enhanced image quality and rapid scans, permit **DCE** imaging with **CBCT**?

METHODS AND MATERIALS

- Characterization of image quality metrics and spatial resolution on CT, HyperSight and standard **CBCT**
- Phantom imaged (Fig. 1) contains capsules mimicking various iodine contrast enhancement levels
- Scans across acquisition settings such as mAs, kVp, detector modes, slice thickness, etc.

Hypothesis

HyperSight will improve **CBCT** image quality with sufficient spatial resolution at faster acquisition speeds

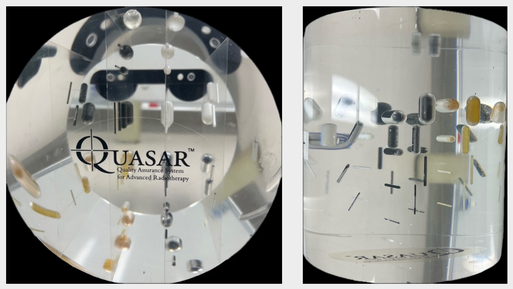

Figure 1. Contrast enhancement phantom with capsules mimicking various iodine contrast enhancement levels.

RESULTS

Variation in CT number across mAs, phantom position:
CT: <0.09%, <0.8%
HyperSight **CBCT** (Halcyon): <0.6%, <3.8%
HyperSight **CBCT** (TrueBeam): <0.3%, <4%
CBCT (TrueBeam): <0.8%, <7.4%

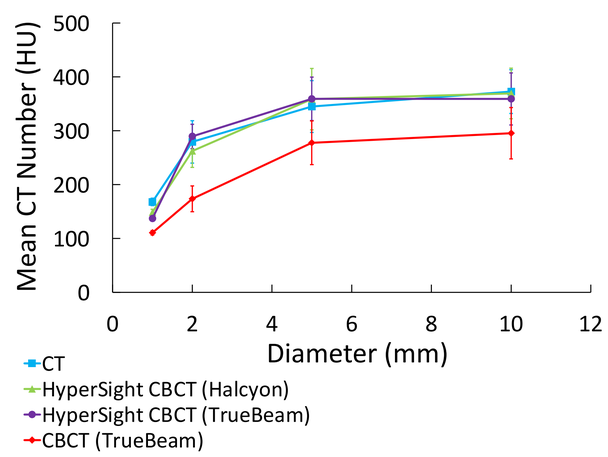

Figure 2. Diameter (mm) by mean CT number (HU) for the axial, 1.56 g/cm³ capsules.

The partial volume effect is shown through a decrease in CT number with capsule diameter (Fig. 2).

Volume accuracy was similar across modalities (1-2%), suggesting similar partial volume averaging.

Accuracy in CT number:
CT: <2.4%
HyperSight **CBCT** (Halcyon):
<3% (FDK)
<0.2% (iCBCT Acuros)
<0.1% (iCBCT MAR)
HyperSight **CBCT** (TrueBeam): <6.4%
CBCT (TrueBeam): <21.2%

Variation across orientations in CT number, volume:
CT: 0.2%, 0.7%
HyperSight **CBCT** (Halcyon):
3.7%, 4% (FDK)
0.9%, 2% (iCBCT Acuros)
0.8%, 1.6% (iCBCT MAR)

Spatial resolution, the 10% threshold of modulation transfer function (MTF) curves, was decreased for diagonal capsules and the x-dimension due to slice thickness (Table 1).

Imaging modality	10% MTF (lp/cm)
CT	2.5 – 6.5
HyperSight **CBCT** (Halcyon)	2.2 – 5.0
HyperSight **CBCT** (TrueBeam)	2.3 – 5.7
CBCT (TrueBeam)	1.8 – 5.7

Table 1. Spatial resolution for the 10 mm, 1.56 g/cm³ capsules, acquired at various reconstruction algorithms.

DISCUSSION

- HyperSight improved image quality over standard **CBCT** for iodine contrast-enhanced objects
- HyperSight displayed greater CT number consistency, accuracy, and volume accuracy
- It maintained spatial resolution and partial volume averaging with minimal reconstruction issues
- HyperSight reconstruction algorithms iCBCT Acuros and MAR displayed improvements over FDK

CONCLUSIONS

- HyperSight demonstrated improved dosimetric accuracy and geometric fidelity over standard **CBCT**
- This supports its potential for consistent and reproducible **DCE** signal quantification during **IGRT**
- Future work will investigate HyperSight sensitivity to motion and temporal resolution

REFERENCES

IGRT: Image-guided radiotherapy

CBCT: Cone beam CT

DCE-CT: Dynamic contrast-enhanced CT

Coolens C, Mohseni H, Dhodi S, Ma S, Keller H, Jaffray DA. Quantification accuracy for dynamic contrast enhanced (DCE) CT imaging: phantom and quality assurance framework. Eur J Radiol 2018;106:192-8.

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