2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

Feasibility of Novel CBCT-based Online Adaptive Radiotherapy In A Cervical Cancer Patient with a Hip Prosthesis

Jasmine Penney, MSc[1]; Krista Chytyk-Praznik PhD[1,2]
[1]Department of Physics and Atmospheric Sciences, Dalhousie University, Halifax, Nova Scotia, Canada
[2]Department of Medical Physics, Nova Scotia Health, Halifax, Nova Scotia, Canada

ABSTRACT

Purpose: When cervical cancer patients with hip prosthesis undergo standard-CBCT imaging, metal artifacts are present in the image due to the prosthesis high-Z material, leading to uncertainty in contouring and dose calculation. With the introduction of HyperSight imaging, metal artifacts are reduced with a metal artifact reconstruction (MAR) algorithm. This work evaluates HyperSight imaging for oART in a LACC patient with a hip prothesis.

Methods: One patient with a hip prothesis (left) was treated for LACC at our institution with HyperSight-CBCT imaging. Six evenly spaced CBCTs (Fraction 1, 5, 10, 15, 20, 25) were used to simulate an adaptive session. Partial arcs were used to avoid beams entering through prosthesis. Image quality was assessed using CNR ratio and artifact index. The quality of contours were evaluated using a scoring system to assess auto-contours, 1 being unacceptable/extensive edits up to 5 being acceptable/no edits. The adaptive plans were also assessed dosimetrically.

Results: Across the five HyperSight CBCT's, mean CNR was 5.0±0.2 (right) and 3.7±0.2 (left), with corresponding artifact indices of 20.9 HU ± 1.8 (right) and 29.8 HU ± 2.0 (left).For the target volume contours, Fraction 1, 5, 10, and 15 required minor to moderate edits and few (1-5% slices) to some edits (6-20% slices) were made, while Fraction 20 and 25 contours were clinically unacceptable, with extensive edits made (>50% of slices). oART was successful for all six fractions, and the adapted plan chosen each time. The CTV $V_{98\%}$≥98% was averaged to be 98.7% for all fractions. The average maximum dose delivered to the rectum, bladder, and bowel bag was 104.0%, 101.0%, and 106.1%, respectively.

Conclusions: This work demonstrates HyperSight CBCT images for oART in LACC patients with hip prostheses. HyperSight images show promise for reliable contouring and accurate dose calculation.

CONTACT

Jasmine Penney
Dalhousie University, Nova Scotia, Canada
jasmine.penney@dal.ca
902-410-6037

INTRODUCTION

- Online adaptive radiotherapy (oART) uses daily CBCT imaging to account for interfractional anatomical changes
- Hip prostheses produce metal artifacts that reduce CBCT image quality and increase uncertainty in contouring and dose calculation
- HyperSight CBCT incorporates advanced image reconstruction and metal artifact reduction to improve image quality
- The feasibility of HyperSight-guided oART for locally advanced cervical cancer (LACC) patients with hip prosthesis has not been well established

Objective: To evaluate the image quality and dosimetric feasibility of HyperSight-guided oART for a LACC patient with a unilateral hip prosthesis

METHODS AND MATERIALS

- One patient with LACC with a left hip prosthesis treated with IGRT on the the Varian Ethos system with a "fallback" plan from Eclipse
- Six HyperSight CBCT images (Fraction 1, 5, 10, 15, 20, 25) acquired during IGRT used to simulate oART sessions in ETM Emulator
- Partial VMAT arcs designed in Eclipse avoided beam entry through the hip prosthesis
- Scheduled and adapted plans in the emulator were compared dosimetrically
- Image quality was evaluated using CNR and artifact index

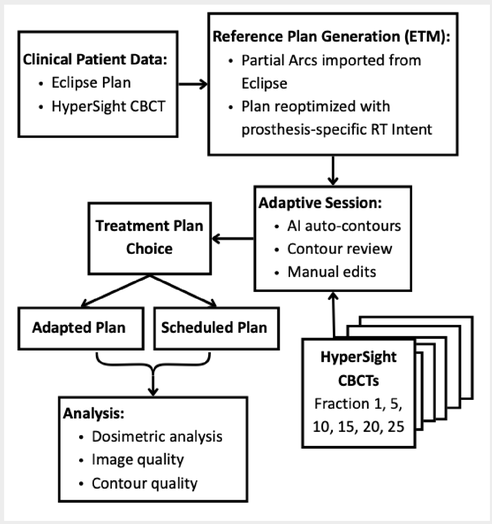

Figure 1. Workflow of the simulated HyperSight oART process evaluated in this study

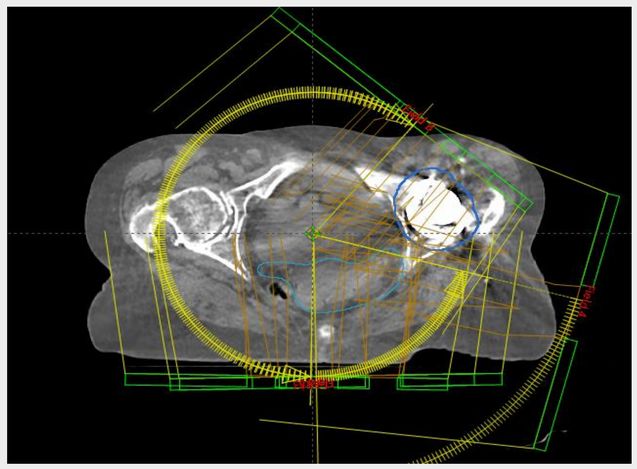

Figure 2. Partial VMAT arcs used to avoid beam entry through the left hip prosthesis

Table 1. Comparison of target and OAR dose metrics between adapted (ADP) and scheduled (SCH) plans for each HyperSight CBCT fraction. Bold values indicate the preferred dosimetric results.

Dose Metric	CBCT 1		CBCT 5		CBCT 10		CBCT 15		CBCT 20		CBCT 25	
	ADP	SCH	ADP	SCH	ADP	SCH	ADP	SCH	ADP	SCH	ADP	SCH
CTV $V_{98\%}$	**99.1**	94.6	**98.4**	92.6	**98.4**	96.9	98.4	**98.7**	**98.9**	98.3	99.1	**99.3**
CTV $D_{98\%}$	**98.4**	97.0	**98.1**	94.6	**98.1**	97.7	98.2	**98.4**	**98.4**	98.1	98.4	**98.5**
PTV D_{max}	**105.8**	107.5	**106.5**	107.0	**105.8**	106.9	**107.6**	108.5	**105.8**	111.7	**106.6**	108.9
Bladder D_{max}	**101.1**	103.3	**101.1**	100.8	**101.7**	102.9	**101.2**	106.6	**100.7**	105.5	**100.4**	103.3
Rectum D_{max}	**103.8**	107.2	**104.5**	106.0	**104.3**	106.7	**103.7**	108.7	**103.7**	110.9	**104.2**	107.7
Bowel Bag D_{max}	**106.6**	107.2	**106.1**	107.0	**105.1**	106.8	**107.6**	108.7	**105.1**	111.7	**106.2**	108.4
Bone Marrow V_{10Gy}	**85.0**	85.8	84.9	84.9	**80.6**	83.8	**82.9**	83.1	**81.0**	81.9	**80.3**	81.3

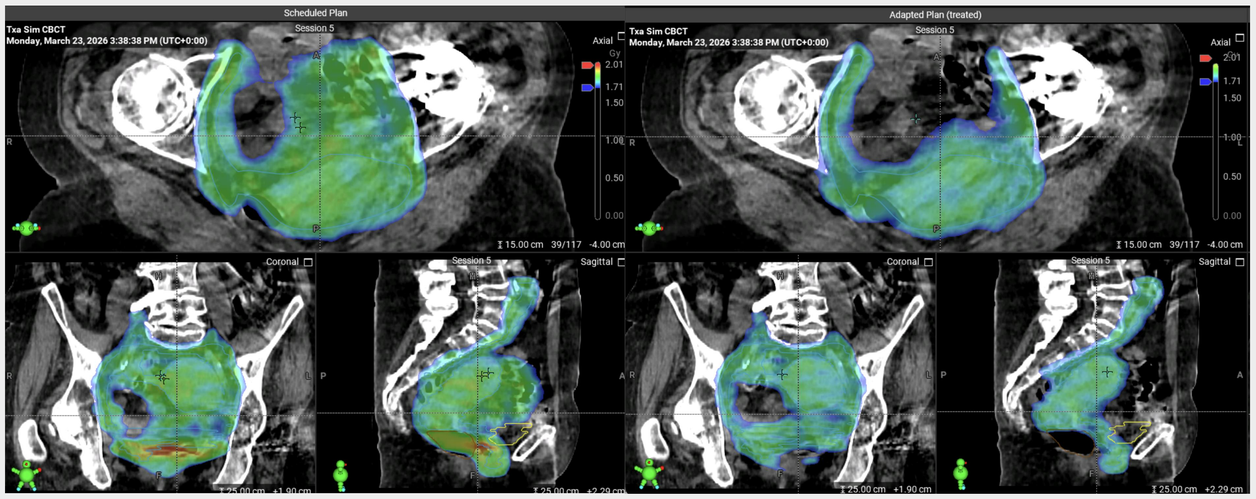

Figure 3. Comparison of scheduled (left) and adapted (right) dose distributions on HyperSight CBCT for Fraction 20. The adapted plan reduced high-dose regions while maintaining target coverage. Dose wash: 1.71-2.01Gy (95-112% of prescribed 1.8 Gy per fraction)

RESULTS

Dosimetric Evaluation:

- Adapted plans maintained clinically acceptable target coverage for all fractions
- Adaptation generally reduced PTV and OAR maximum doses compared with scheduled plans,

Image Quality:

- HyperSight CBCT provided good visualization of the pelvic anatomy despite the presence of the hip prosthesis
- Higher CNR on the contralateral side (CNR: 5.0 ± 0.2) than on the prosthesis side (3.7 ± 0.2)
- Higher artifact index adjacent to the prosthesis (29.8 ± 2.0 HU vs 20.9 ± 1.8 HU)

Contour assessment:

- Bladder and rectum auto-contours generally required minimal manual editing
- CTV required greater manual refinement

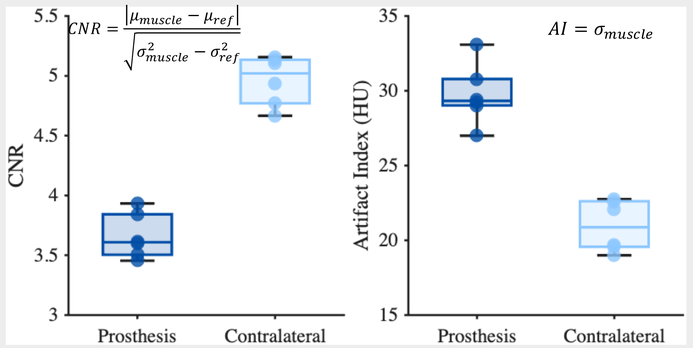

Figure 4. Comparison of CNR and artifact index between the prosthesis and contralateral sides across six HyperSight CBCT fractions. Boxplots show median and interquartile range, with individual points representing each treatment fraction.

DISCUSSION

- HyperSight guided oART was simulated for all six treatment fractions in a patient with a left sided hip prosthesis
- Partial arcs effectively avoided beam entry through the prosthesis while maintaining clinically acceptable target coverage
- Adapted plans generally reduced PTV and OAR maximum dose with scheduled plans while preserving target coverage
- HyperSight CBCT provided sufficient image quality for adaptive planning, despite metal artifacts
- Further studies should include larger patient cohorts are needed to validate these findings

CONCLUSIONS

- HyperSight enabled successful simulation of online adaptive radiotherapy for all six fractions
- Although metal artifacts increased image noise near the prosthesis, image quality remained sufficient for adaptive planning
- Adapted plans maintained clinically acceptable target coverage while reducing maximum doses to several OARs
- HyperSight showed promise for LACC patients with metallic hip prosthesis

REFERENCES

1. Robar JL, Cherpak A, MacDonald RL, et al. Novel technology allowing cone beam computed tomography in 6 seconds: a patient study of comparative image quality. *Pract Radiat Oncol*. 2024;14(3):277-286
2. Webster M, *et al*. Cone-Beam Computed Tomography (CBCT)-Based Online Adaptive Radiation Therapy (oART) for a Prostate Cancer Patient With Inflammatory Bowel Disease and Bilateral Total Hip Arthroplasty: A Case Report. Cureus. 2024 Sep 9;16(9):e68990