Quantitative Evaluation of Auto-Contouring Algorithm Performance on HyperSight versus Traditional CBCT

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OVERVIEW

- ► Cone-beam CT (CBCT) is integral to image-guided and adaptive radiotherapy (ART), providing daily anatomical verification and plan adaptation [1,2]
- ► Traditional CBCT suffers from scatter artifacts, poor soft-tissue contrast, and inaccurate Hounsfield units, limiting its role beyond patient positioning [3,4]
- ► HyperSight CBCT (HS-CBCT) incorporates hardware and algorithmic advances that substantially reduce artifacts and improve HU fidelity approaching diagnostic CT [5-6]
- ► Auto-contouring is essential for efficient ART workflows but has shown inconsistent performance on traditional CBCT due to image quality constraints [7,8]
- ► HS-CBCT's improved image quality may enable reliable on-board auto-segmentation, but rigorous clinical validation is required before adoption

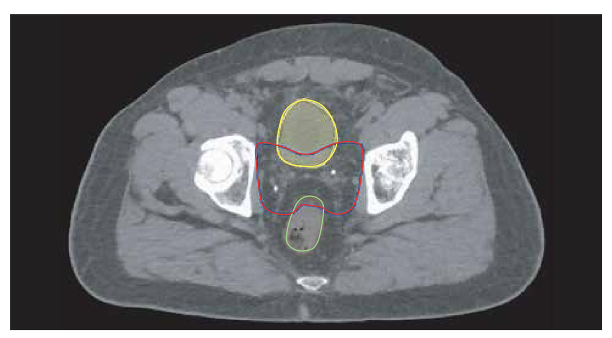
Here we evaluate a commercial auto-contouring algorithm applied to planning CT (pCT), HyperSight CBCT (HS-CBCT), and traditional CBCT (tCBCT) in prostate cancer patients. We assess segmentation accuracy and dosimetric impact to determine whether HS-CBCT is a viable substrate for automated contouring in adaptive radiotherapy workflows

METHODS

Study Workflow

► For each patient, pCT and daily CBCT images (HS-CBCT and tCBCT) were exported, registered, and submitted to both physician contouring and automated segmentation for parallel evaluation

Planning CT & Plan



Daily CBCT

HS-CBCT

tCBCT

M.D. Contours

Radformation Auto-Contours

Patient Population

- ► 4 prostate SBRT patients
- ► Daily IGRT utilized either tCBCT and HS-CBCT resulting in registered pairs of planning and CBCT scans.

Contour Generation

- ► Contours were generated on all patient images (pCT, tCBCT, and HS-CBCT) using AutoContour (Radformation, New York, NY) without editing
- ► Physician reviewed & edited AI-generated contours to generate ground-truth contours on each image

Evaluation Metrics

Dice Similarity Coefficient (DSC)
Quantifies the volumetric overlap between two contour sets (0-1)

Added path length (APL)
Quantifies the total length of contour that requires modification from the auto-generated contour to the reference contour

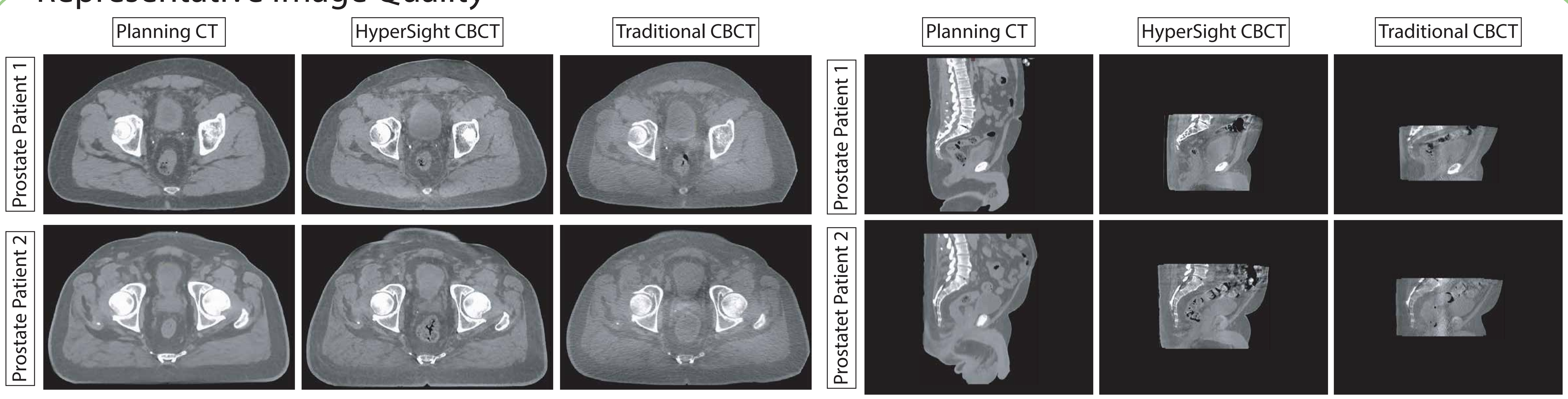
Structural Similarity Index Measure (SSIM)
Evaluates spatial structural similarity between contour representations (0-1)

95th Percentile Hausdorff Distance (HD95)
Quantifies the maximum surface discrepancy between two contour boundaries

Physician Evaluation
Rating Scale : (3) acceptable, (2) minor edits needed, or (1) major edits needed

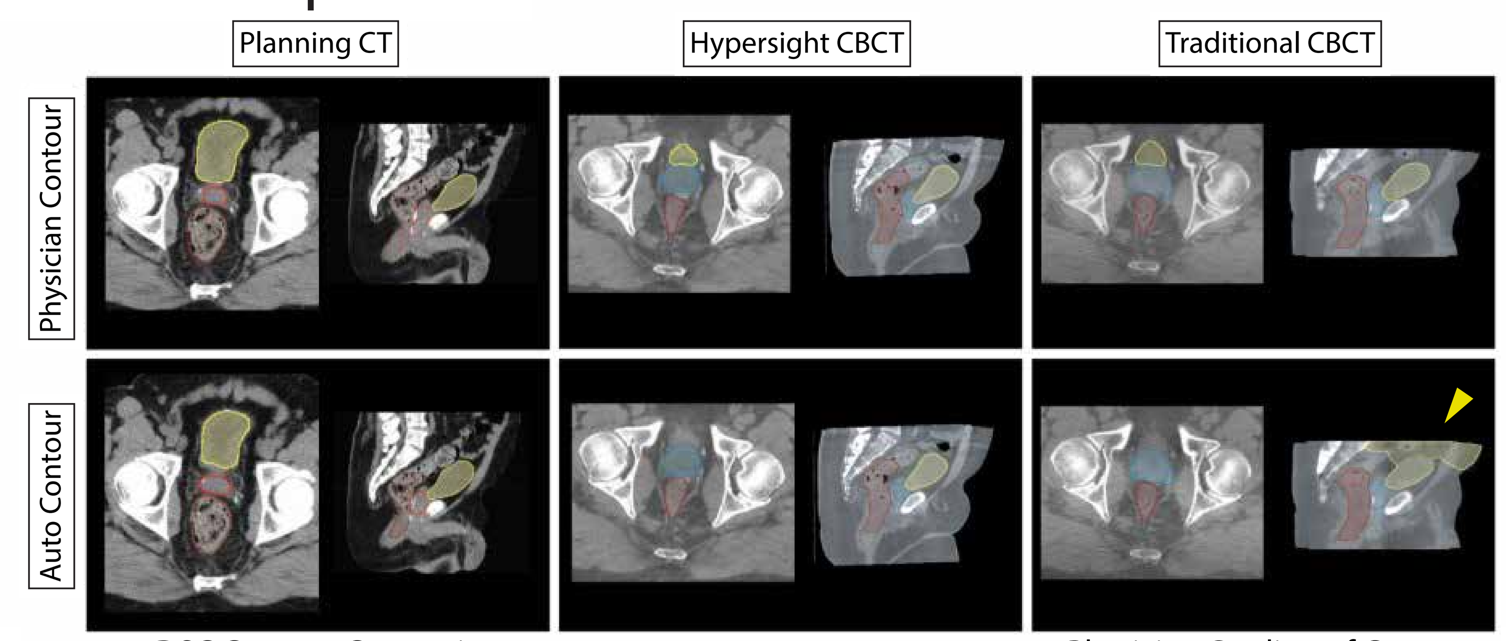
Statisical Evaluation
Independent samples t-tests were used to compare group means, with statistical significance set at $p < 0.05$.

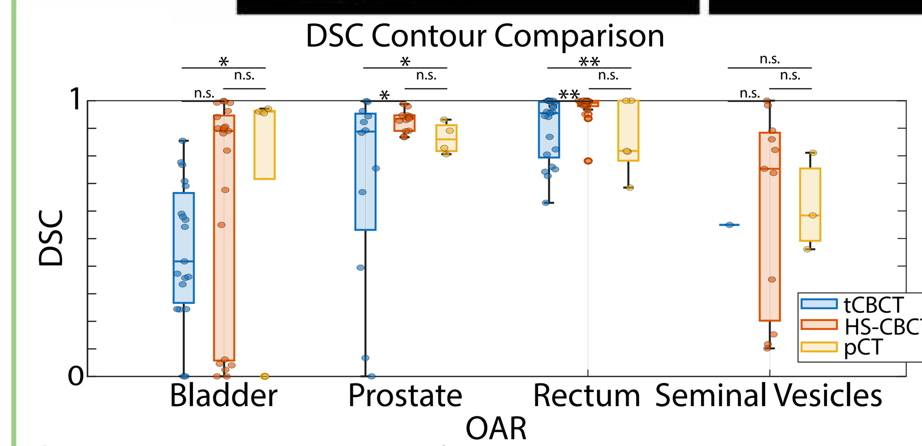
Representative Image Quality

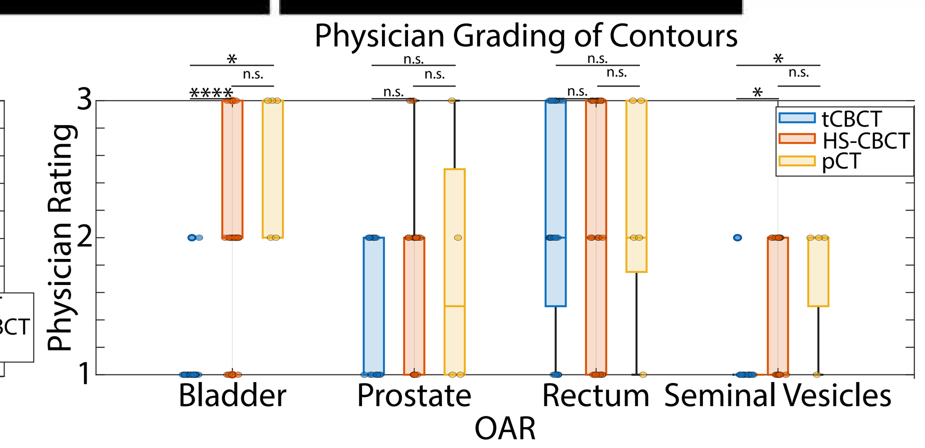


RESULTS

Contour Comparison







Contour Accuracy Metrics

- ► Auto-contouring achieved superior geometric accuracy on HS-CBCT versus tCBCT across all structures, with mean DSC improvements of 0.04–0.48 points, approaching or exceeding pCT performance levels
- ► HS-CBCT reduced boundary discrepancies (HD95) relative to tCBCT for well-defined structures (prostate, bladder), with values converging toward pCT baseline (mean difference <2 mm)
- ► Added path length (APL) was 7–30% lower on HS-CBCT versus tCBCT, suggesting meaningfully reduced manual editing burden for clinical adoption of auto-contours in online adaptive workflows
- ► Auto-contouring failed to contour the seminal vesicles on all but 1 tCBCT due to the image quality

Physician Acceptability

- ► Across all structures, 68% of HS-CBCT contours required no or only minor edits (Score 1–2), versus 37% for tCBCT
- ► Physician ranking of auto-contours strongly favored HS-CBCT: 16% scored as 1 (acceptable without edits) on HS-CBCT versus 11% on tCBCT, compared against pCT (33%)
- ► Differences in physician preference exhibited significance in the bladder & seminal vesicles consistant with the quantitative metrics

Discussion

- ► HS-CBCT enabled successful autocontouring across all patients, whereas autocontouring failed on multiple tCBCT images from the same cohort. In cases where both methods succeeded, HS-CBCT demonstrated improved geometric similarity metrics compared to tCBCT
- ► These findings support the hypothesis that scatter reduction and improved HU fidelity in next-generation onboard imaging directly benefit downstream segmentation tasks rather than simply improving visual image quality for manual review
- ► While improvements were observed across the successfully contoured cases, the small sample size (n=4) and autocontouring failures preclude definitive conclusions about whether benefits reflect fundamental image quality improvements or patient-specific factors
- ► These preliminary results suggest HS-CBCT warrants further investigation as a potential tool to reduce manual editing; however, larger studies with more robust autocontouring performance are needed to establish clinical utility
- ► Importantly, these gains were achieved without any modification to the auto-contouring algorithm itself, indicating that imaging hardware and reconstruction improvements alone could meaningfully extend the clinical utility of existing commercial segmentation tools to the online adaptive setting

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