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Imaging Quality Of A High-Performance Cone-Beam Computed Tomography Imaging System

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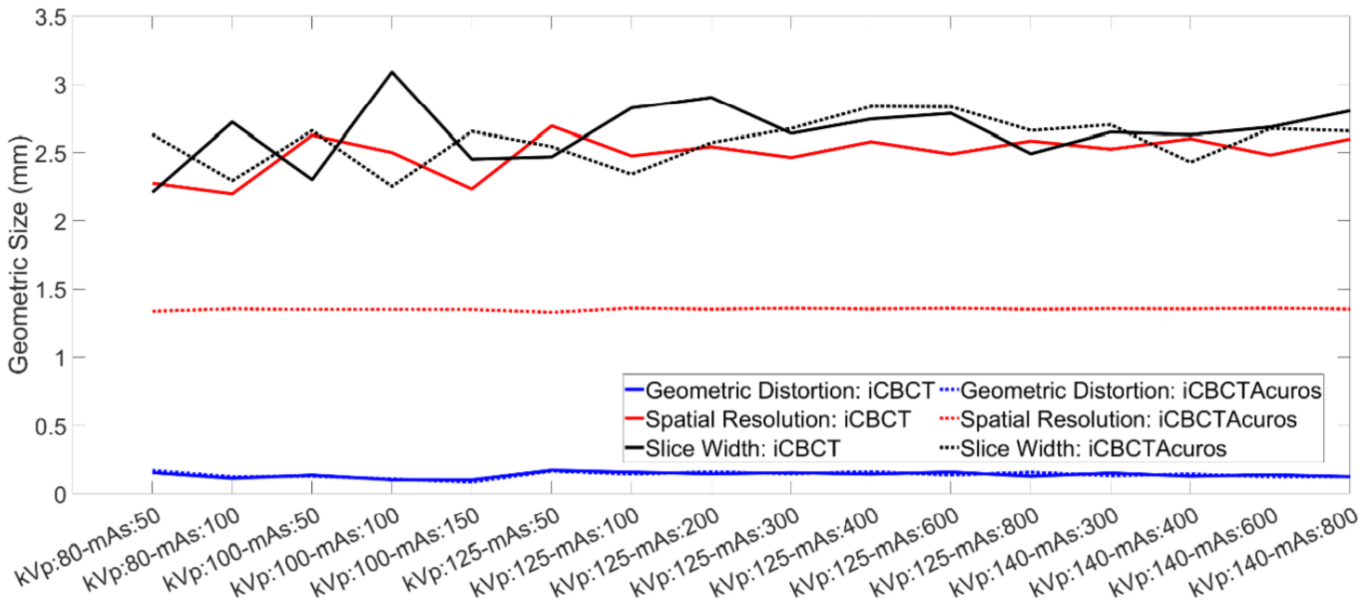
PURPOSE / OBJECTIVES

The current standard of care in radiotherapy involves using cone-beam CT (CBCT) to localize tumors localized within soft tissue. However, the utilization of CBCT imaging is compromised by poor noise and contrast resolution due to physical and engineering constraints. Therefore, this study aims to report on the imaging quality of a novel high-performance CBCT system (HyperSight^{TM})

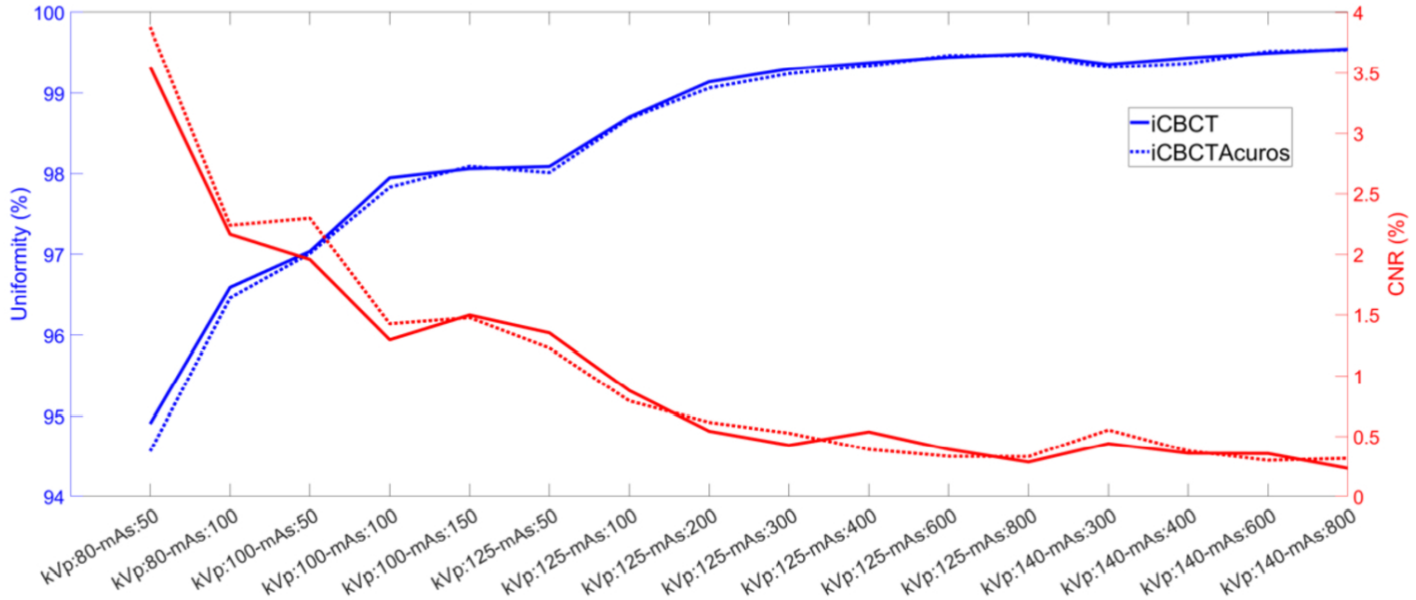
MATERIAL & METHODS

A re-engineered CBCT imaging panel with the size doubled to 86cm x43cm for a full field of view (FOV) of 55.8cm in diameter and extendable to 70 cm was installed by the vendor on a commercial o-ring linear accelerator. The gantry rotation speed was increased to 10 rotations per minute. Combined with the new imaging panel, a 211o rotation was deemed enough for a full CBCT reconstruction. This improvement reduced the acquisition time to 5.9 seconds. Imaging quality has been drastically improved due to the use of 280 um of Cesium Iodine scintillation layer. Compared to GOS, CsI has higher light yield and its columnar surfaces restricts the spread and diffusion of light which results in higher intrinsic resolution with increased light density. Meanwhile, a closer anti-scatter grid improve imaging contrast by reducing scattering. A new iterative CBCT reconstruction algorithm based on a Boltzmann solver is also released for enhanced imaging quality.

CatPham was used to check the imaging quality and analyzed with DoseLab for a variety of clinical protocols reconstructed with two reconstruction modes: iterative CBCT reconstruction (iCBCT) and iterative CBCT reconstruction with correction for scatter (iCBCTAcuros). Specifically, module CTP404 was used to evaluate geometric accuracy and slice thickness by checking the position and alignment of the four 50mm spaced rods and the four 23o ramps. Module CTP528 was used to evaluate imaging resolution by determining the differentiability of the embedded 21 high-contrast line pairs and the modulation transfer function (MTF) of the embedded point source. Module CTP515 was used to determine the contrast-noise ratio with three sets of embedded low contrast targets of various diameters at contrast levels of 0.3%, 0.5%, and 1%, respectively.



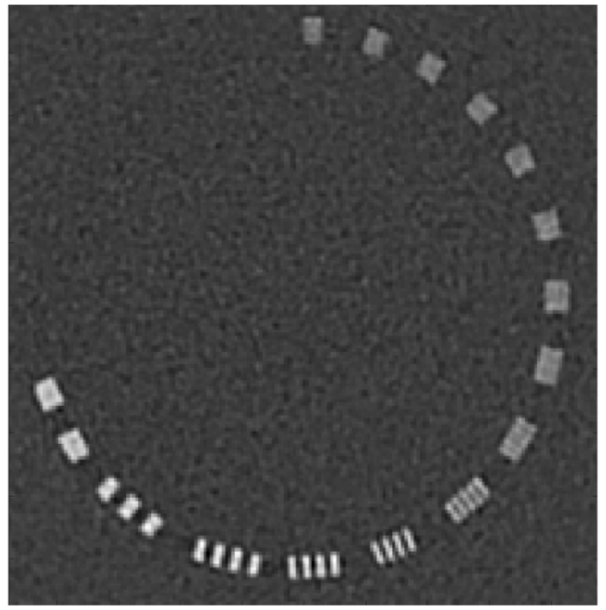
Measured geometric parameters in images acquired with a variety of tube voltage and exposure-time combinations and comparison between iCBCT and iCBCTAcuros reconstruction.



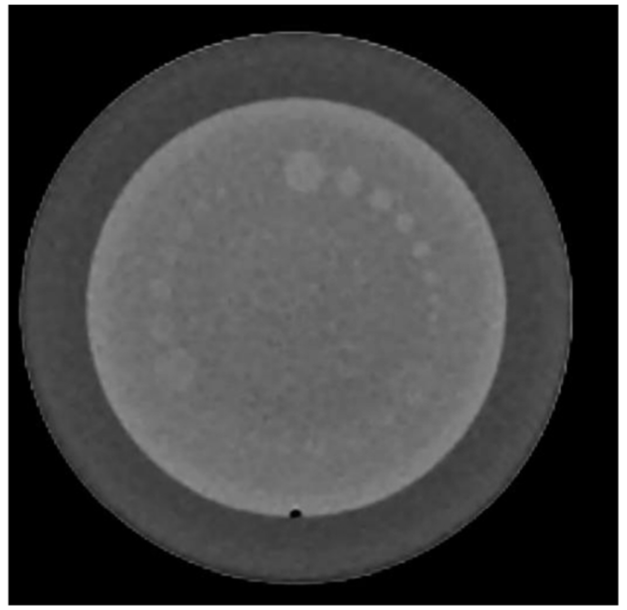
Measured geometric parameters in images acquired with a variety of tube voltage and exposure-time combinations and comparison between iCBCT and iCBCTAcuros reconstruction.

RESULTS

Geometric distortion and slice thickness were measured as 0.14 mm ± 0.02mm and 2.62 mm ± 0.20 mm, respectively. No noticeable difference was observed between the two CBCT reconstruction modes. However, the imaging resolution was 1.35 mm ± 0.01mm and 2.49 mm ± 0.14mm at 50% MTF reconstructed in iCBCT and iCBCTAcuros modes, respectively. The smallest detectable targets were 2 mm, 3 mm, and 4 mm for 1%, 0.5%, and 0.3% contrast, respectively.



Resolution bars



Low Contrast

SUMMARY / CONCLUSION

The imaging quality of the novel high-performance HyperSight^{TM}CBCT system is comparable to that of a typical helical simulation CT..

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