kV CBCT Image Quality Evaluation of Varian Halcyon HyperSight

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INNOVATION/IMPACT

HyperSight is a newly FDA cleared Varian imaging system with improved image quality, precision, and faster CBCT speed. This study shows a detailed evaluation of Varian HyperSight kV CBCT image quality.

METHOD

Varian Halcyon HyperSight provides four kV settings for CBCT: 80kV, 100kV, 125kV, 140kV and four different CBCT reconstruction methods, including FDK, iCBCT, iCBCT Acuros, and iCBCT MAR (metal artifact reduction).

In this evaluation, HyperSight CBCTs for all energies with all reconstruction methods were scanned using Catphan 604. The CBCT image qualities were analyzed using ImageOwl CBCT analysis tool, including

- geometry distortion
- spatial resolution
- contrast
- HU constancy
- HU uniformity
- noise
- line spread function
- modulation transfer function
- linearity
- HU accuracy

The results were evaluated and compared to Varian TrueBeam CBCT.

Finally, the image quality was compared among fan-beam simulation-CT, HyperSight CBCT and TrueBeam CBCT on a patient treated on both TrueBeam and Halcyon.

RESULTS

Table 1. Summary of kV CBCT basic image quality of Halcyon HyperSight

kV setting	CBCT Quality	HyperSight CBCT reconstruction method				TrueBeam
		Standard	iCBCT	iCBCT Acuros	iCBCT MAR	
80	Geometry distortion (mm)	0	0.02	0.06	0	
	Spatial resolution (lp/cm)	4.44	4.29	3.98	4	
	Contrast (1% level) (mm)	15	15	15	15	
	HU constancy (HU)	32	35	45	33	
	Uniformity (HU)	33.9	18.9	28.5	41	
100	Geometry distortion (mm)	0	0	0.03	0.03	0.03
	Spatial resolution (lp/cm)	4.36	4.76	4.27	4.76	7.3
	Contrast (1% level) (mm)	7	8	8	8	9
	HU constancy (HU)	14	18	12	10	40
	Uniformity (HU)	23.1	18.4	5.8	10.1	10
125	Geometry distortion (mm)	0	0	0.03	0.02	0.08
	Spatial resolution (lp/cm)	4.48	4.42	4.24	4.49	4.65
	Contrast (1% level) (mm)	4	4	4	4	15
	HU constancy (HU)	18	15	7	6	45
	Uniformity (HU)	24	23.8	5.1	6.1	17
140	Geometry distortion (mm)	0	0.03	0.03	0.06	
	Spatial resolution (lp/cm)	4.32	3.9	3.98	4.25	
	Contrast (1% level) (mm)	3	3	3	3	
	HU constancy (HU)	17	17	7	6	
	Uniformity (HU)	24.6	23.7	9.6	9.5	

fan-beam simulation-CT

HyperSight CBCT

TrueBeam CBCT

Figure 1. Comparison of simulation-CT, HyperSight CBCT and TrueBeam CBCT for the same patient. Top figures are fan-beam simulation-CT, middle figures are HyperSight CBCT, and bottom figures are TrueBeam CBCT.

A summary of kV CBCT image quality of Halcyon HyperSight was shown in **Table 1**. The Acuros reconstruction showed better HU uniformity for 100kV, 125kV and 140 kV CBCT compared to other reconstruction methods. The Acuros reconstruction also showed significantly better HU uniformity compared to TrueBeam CBCT for 100kV and 125kV CBCT. All HyperSight reconstruction methods showed significantly better contrast and HU constancy relative to TrueBeam CBCT. TrueBeam CBCT had better spatial resolution than the HyperSight scans. Our measured materials' (air, polystyrene, acylic, and teflon) HU for 100kV and 125kV of the Acuros reconstruction were all within 16HU from the Varian specification.

Figure 1 shows a comparison of image quality among fan-beam simulation-CT, HyperSight CBCT and TrueBeam CBCT on a H&N patient treated in our clinic. The image quality of HyperSight CBCT was similar to fan-beam simulation-CT, and was significantly superior to TrueBeam CBCT.
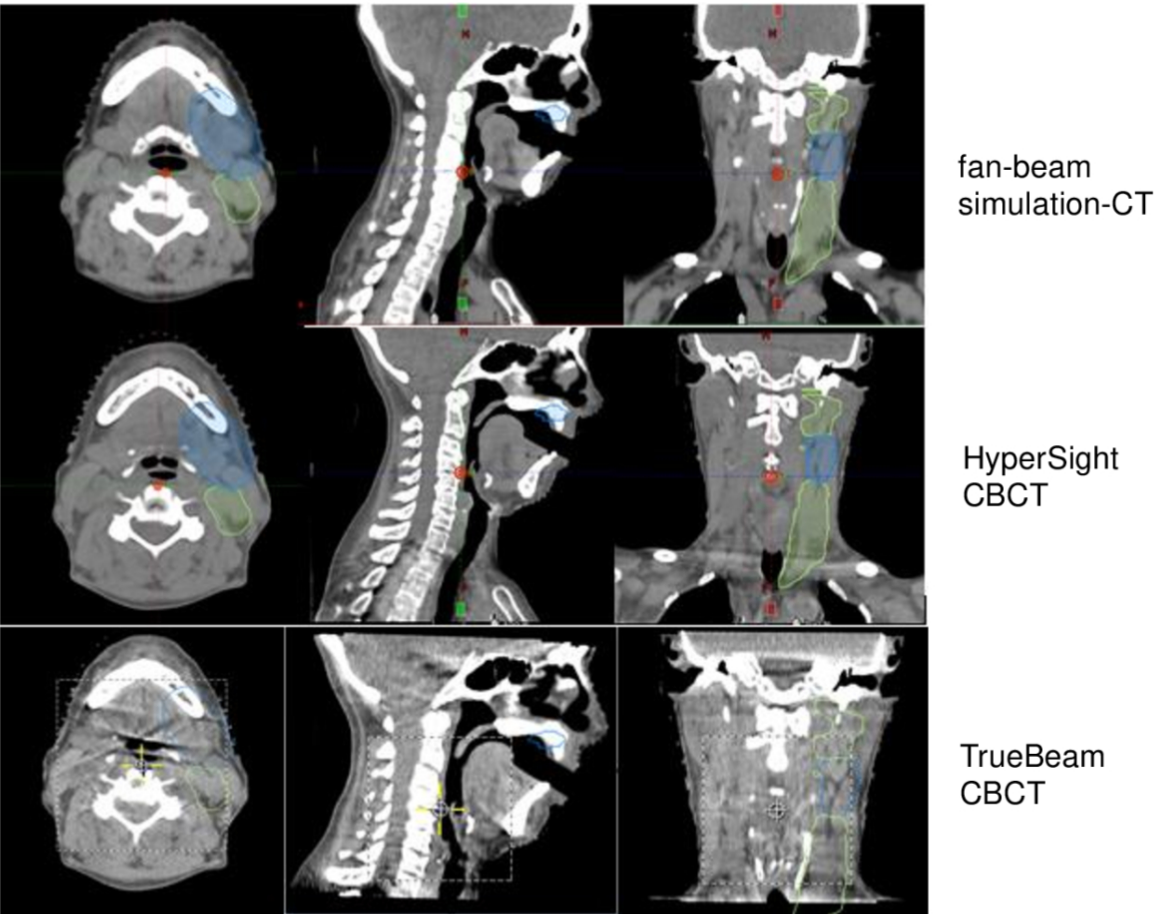
CONCLUSIONS

Halcyon HyperSight CBCT trades some spatial resolution for a dramatic increase in contrast to noise ratio, which results in near fan-beam CT quality. The Acuros reconstruction has better image contrast, HU constancy and HU uniformity compared to TrueBeam CBCT, and has better HU uniformity than other reconstruction methods. HyperSight with iCBCT Acuros reconstruction is well-suited for adaptive planning.

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