Improving CBCT image quality for obese patients using a unified scatter rejection and correction method

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INTRODUCTION

- Quality of CBCT images deteriorates substantially for obese patients due to higher fluence of scattered radiation.
- Recently introduced 2D antiscatter grids can reduce scatter subtantially[1]. However, a small fraction of scatter fluence is transmitted through the 2D grid[2,3], which may degrade image quality.

AIM

- Hence, we developed a new method to correct residual scatter transmitted through the 2D grid.
- In this method, 2D grid's role was expanded from a scatter rejection device to a scatter measurement and correction device. This new method is referred as "**Grid-based scatter sampling (GSS)**".
- In this work, we compared the imaging performance of our method in the context of obese patient imaging.

METHOD

GSS operation basics:

- 2D grid's septa act as a micro beam stop array, and septal shadows introduce a signal modulation pattern in projections.
- The signal modulation amplitude (the ratio of pixel values in the grid holes to pixel values in the grid septal shadows) is altered by scatter. This change in amplitude is proportional to the residual scatter fluence. In GSS, we measure this change in amplitude and correlate it with scatter intensity in the image signal. See reference #4 for details.
- We used the GSS method and 2D grid in imaging of large phantoms that emulate obese patient geometry in a linac mounted CBCT system.
- We evaluated the HU accuracy with respect to clinical CBCT scans and helical CT.

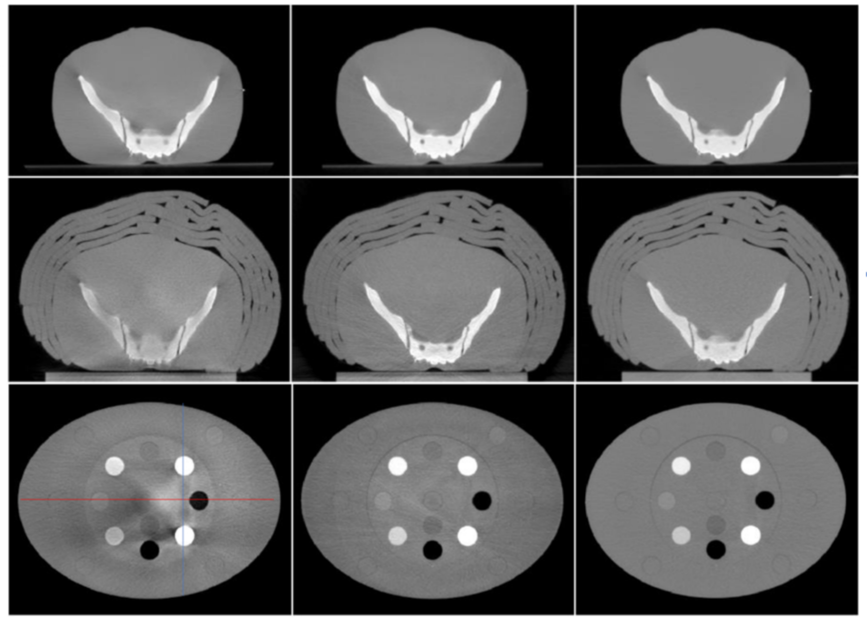
RESULTS

Image acquisition and reconstruction parameters

- *Varian TrueBeam half-fan CBCT, with bow tie filter, 125 kVp*
- ***TrueBeam Clinical CBCT protocol:** Includes conventional grid, scatter correction with pencil beam kernel, beam hardening correction, FDK reconstruction.*
- ***CBCT with 2D antiscatter grid:** Residual scatter correction with GSS method. FDK reconstruction. No other data correction methods were used.*
- ***2D antiscatter grid:** Grid pitch: 2mm, Grid ratio:12*
- ***Helical CT:** Philips Big Bore CT, 16 x 1.5 mm collimation*
- *All CBCT images were acquired using the same dose.*

Fig. 1. The effect of phantom size and material density on images

	Clinical CBCT protocol	*2D grid + GSS CBCT*	*Philips Helical CT*
Standard pelvis			
Obese pelvis			
Electron density phantom			



- *The percent change, or degradation, in HU values (K_{HU}) due to change in pelvis phantom size is shown in Fig. 2.*

$$K_{HU} = 100 \frac{|HU_{standard\ pelvis} - HU_{obese\ pelvis}|}{HU_{standard\ pelvis}}$$

- *HU profiles along the red and blue lines are shown in Fig. 3.*

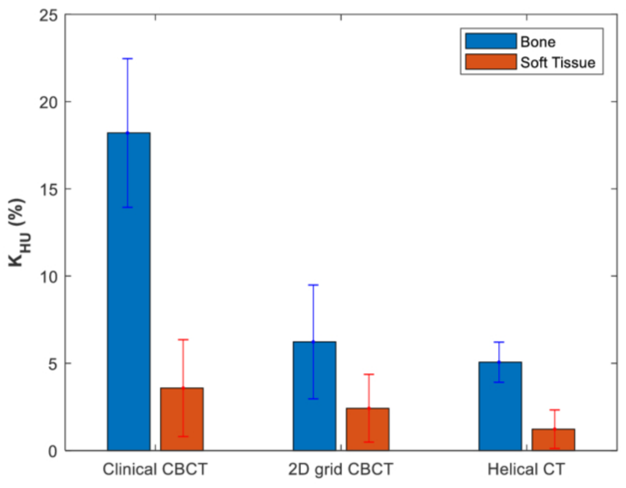


***Fig. 2** . Percent change in HU values, K_{HU} , when pelvis phantom size was increased from standard to obese. Ideally, K_{HU} should be zero.*

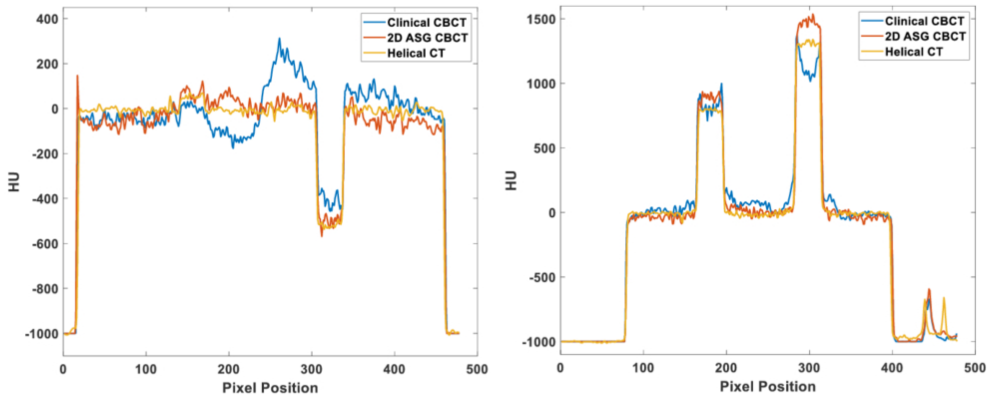


***Fig. 3** . HU profiles along the lines in electron density phantom in Fig. 1. **Left:** red line segment. **Right:** blue line segment.*

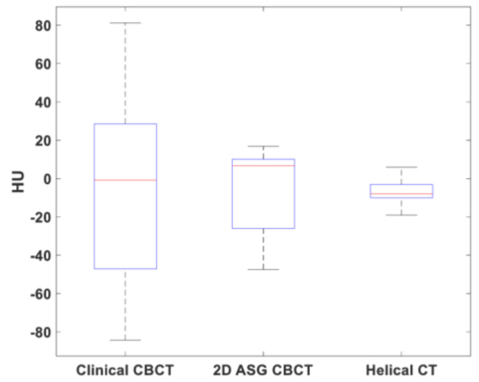


***Fig. 4** . HU nonuniformity in 9 ROIs selected in the water-equivalent sections of the electron density phantom. Whiskers: min-max HU, box: 25th-75th percentiles, red line: median HU value*

CONCLUSIONS

With 2D grid + Grid Based Scatter Sampling (GSS) :

➔ CBCT HU accuracy closer to helical CT.

➔ Better HU accuracy and less artifacts than conventional CBCT scatter mitigation methods.

➔ Particularly better image quality in CBCT images of large patients and high-density objects, where scatter fraction is high in projections.

Potential utility of GSS method is in CBCT-based dose calculations and quantitative imaging methods, such as dual-energy CBCT.

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