Characterizing the HU Constancy of the Varian Ethos HyperSight CBCT and Comparing it to Conventional Systems

Clara J. Fallone1,2, Lee MacDonald1,2,3, Amanda Cherpak1,2,3, James Robar1,2,3

Dalhousie University, Department of Physics and Atmospheric Science, Halifax, Canada
Nova Scotia Health, Department of Medical Physics, Halifax, Canada
Dalhousie University, Department of Radiation Oncology, Halifax, Canada

Introduction

-Preliminary research suggests that the Varian Ethos HyperSight imaging system yields superior image quality compared to Varian TrueBeam cone-beam computed tomography (CBCT) scanner2 and comparable quality compared to a computed tomography (CT) simulator (GE Optima CT580RT)3.

-Scatter across the large detector area in conventional CBCT degrades image quality, preventing the use of Hounsfield unit (HU) data acquired from CBCT without corrections.2

-The improved quality of HyperSight images compared to conventional CBCT images and their use in plan recalibration during adaptive planning justifies exploring the HU constancy of HyperSight.

-This research acquired the HU to relative electron density (RED) curve using the HyperSight Ethos. Results were compared to that acquired using a TrueBeam CBCT and a GE fan-beam CT Simulator (FBCT).

- The effect of direct exposure of the imaging panel was also explored by varying imaging blade collimation and using additional phantom solid water extensions in HyperSight.

Objectives

To characterize the HU constancy of the Varian Ethos HyperSight CBCT and compare it to conventional systems.

Materials and Methods

-HU to RED curves were generated for each of HyperSight CBCT and conventional FBCT (GE Optima CT580RT) and CBCT (Varian TrueBeam) using the Sun Nuclear Advanced Electron Density (AED) phantom (Figure 1). Imaging parameters are indicated in Table 1.

-For each image, the mean CT value and standard deviation of each insert was quantified from a 12x12 cm² ROI in Eclipse.

-A HU to RED curve was constructed from the expected (manufacturer) insert RED and the measured CT numbers. Separate linear functions were fit to the data for HU ≤ 0 and for HU > 0. Calculated RED values for each insert were obtained from the HU to RED curves. The calculated RED values were compared to the expected RED values; average and maximum absolute % differences were computed and compared. Images were acquired for various HyperSight protocols using a) blade collimation to the full SUP-INF extent of the phantom with additional 5 cm solid water extensions on both phantom ends (13x13 cm² blades, no direct panel exposure), b) the phantom without extensions and without blade collimation for the full SUP-INF extent (13x13 cm² blades, direct panel exposure), and c) with blade collimation for the full SUP-INF phantom extent without extensions (8x8 cm² blades, no direct panel exposure). HU accuracy in each case was assessed using the same methodology described above.

Table 1. Imaging parameters

<table>
<thead>
<tr>
<th>Modality</th>
<th>kVp</th>
<th>mAs</th>
<th>CTDI (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HyperSight pelvis</td>
<td>125</td>
<td>470</td>
<td>8</td>
</tr>
<tr>
<td>HyperSight pelvis large</td>
<td>140</td>
<td>527</td>
<td>14</td>
</tr>
<tr>
<td>HyperSight head</td>
<td>100</td>
<td>88</td>
<td>2</td>
</tr>
<tr>
<td>HyperSight thorax</td>
<td>125</td>
<td>308</td>
<td>6</td>
</tr>
<tr>
<td>CBCT pelvis</td>
<td>125</td>
<td>518</td>
<td>8</td>
</tr>
<tr>
<td>FBCT pelvis</td>
<td>120</td>
<td>115</td>
<td>8</td>
</tr>
</tbody>
</table>

Results

-HyperSight and FBCT yield comparable percent difference magnitude, whereas TrueBeam CBCT displayed more significant deviations, particularly for low RED (Figure 2).
-For all Ethos protocols tested, the HU to RED curves agreed within measured error (Figure 3). Calculated RED values from scans without collimation displayed larger differences with expected RED values; however maximum deviations were all below 4.2%. Using phantom extensions did not appear to affect results.

Conclusions

HyperSight shows superior HU constancy to TrueBeam CBCT and comparable constancy to GE FBCT. Omitting imaging blade collimation potentially degraded HU constancy results; however results agreed within error.

References