Purpose: In image-guided radiotherapy (IGRT), cone-beam CT (CBCT) scan parameters do not take into account patient size information, which can result in unnecessary dose. So-called "smart scans" in radiology attempt to customize exposure parameters to reduce dose without sacrificing image quality. This work presents the feasibility of tube current modulation as a dose reduction technique in CBCT-based IGRT.
Methods: A CATPHAN® phantom with water-equivalent annulus was used to evaluate noise. A CIRS phantom was used to evaluate dose characteristics. Gies et. al.[Med Phys, 26:1999], tells us that noise for the central pixel is minimal for tube current modulated by the square root of the given angular attenuation. This formulation is used to calculate modulation factors for each 10 degree imaging arc. Modulated image dataset was generated by compositing projection data from scans performed with each modulated current setting. Noise characterization was performed by analyzing the standard deviation of the uniformity section of the CATPHAN. Imaging dose was measured using an ionization chamber located in the phantom. For the modulated scan, each ten degree segment was measured separately and then accumulated to get a composite dose reading.
Results: Central axis dose reduction of 31% was attained using this modulation scheme. Visual inspection of a modulated CBCT slices shows appreciable image quality relative to the conventional CBCT. The noise characteristics of the modulated scan were about 20 HU worse than a conventional scan, likely due to the presence of scatter in the enlarged CATPHAN phantom because theoretical predictions are based on primary beam attenuation alone
Conclusions: Initial results demonstrate that the use of a modulated scanning technique, developed by taking into account patient anatomic variation, may be a feasible method to reduce dose while preserving image quality in CBCT-based IGRT.