CHARACTERIZATION OF SIEMENS FORCE CT BOWTIE FILTERS

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ABSTRACT

Purpose: To characterize the four bow tie filters (BTF) (two head and two body) on a dual-source Siemens FORCE CT scanner through non-invasive means by using a real-time dosimeter.

Methods: The Characterization of Bowtie Relative Attenuation (COBRA) method, developed by JM Boone1 and further elaborated by BR Whiting2, was augmented with additional beam quality measurements (HVLs). A 0.6 cm ion chamber was positioned near the periphery of the scan field of view for each of the two CT kV sources (Tube A and Tube B); the detector remained stationary while the tubes were separately activated and rotated around the detector; the tube collimation was open to its maximum so that the x-ray cone-beam encompassed the dosimeter throughout its rotation. Measurements were made at 80 and 120 kVp. The acquired dose-rate waveforms were distance corrected and then fitted to a polynomial equation for smoothing purposes. Additional stationary tube exposure measurements were obtained at three different fan angles in order to better characterize the quality of the x-ray beam (HVLs of Al) through different amounts of BTF material. The BTF thickness was then determined in mm of aluminum-equivalent thickness relative to the center of the filter for the four BTFS.

Results: The shapes of the bow tie filter profiles determined for the two energies had the expected shape and were in close agreement with each other (e.g., the max thickness deviation between the two profiles for the Tube B head filter was 0.20 mm). The body BTF thickness profiles for both tubes were in good agreement with published results utilizing a different method2; no published head BTF was available for comparison.

Conclusions: We have determined the shape and relative thickness of four BTFS (two head and two body) used in a Siemens FORCE CT scanner in units of mm of aluminum-equivalent thicknesses by incorporating measurements of HVLs at various fan beam angles with the COBRA method.

INTRODUCTION

Computed tomography (CT) scanners use a bowtie filter (BTF) to improve dose utilization by shaping the beam to better complement the shape of a patient. The BTF is thinner for the central ray and becomes increasingly thicker with increasing fan angle, thus giving the filter its characteristic bowtie shape. Some advantages to using a BTF are: reduced detector dynamic range requirements1, reduced dose to the periphery of the patient, and reduced scatter – resulting in a better image signal-to-noise ratio1. Most modern CT scanners use two BTFs of different sizes: one for head and one for body imaging. Properties of BTFs such as thickness and composition are proprietary. Knowledge of these properties would allow for characterization of photon fluence and, therefore, a better estimation of the patient dose when simulating (via Monte Carlo) the scanning environment. The traditional method of estimating the BTF shape requires a stationary tube and series of dosimetry measurements of the x-ray beam in the fan angle direction1. Such a method requires special scanner permissions to park the tube, which most sites do not have. In contrast, the “characterization of bowtie relative attenuation (COBRA)”1 uses a real-time dosimeter to measure a dose rate waveform during a single gantry rotation. This data, when combined with source-to-detector distance corrections and HVL measurements, can be used to determine the BTF profile1.

METHODS AND THEORY

A Radial 10X6-0.6 high dose rate ion chamber (0.6 cm³ active volume) was connected to a Radial Accu-Gold®-digitizer module (10 kHz sampling rate) and positioned as close as the edge of the scan field of view (SFOV) as possible in order to sample a large range of fan angles. For each tube (A & B) and each BTF (head & body) combination, an 80 kVp and 120 kVp measurement was obtained with following shared scan parameters: (1) 1 tube rotations at 0.5 sec/rot, (2) 50 mA tube current, and (3) a CT detector configuration of 96x0.6 mm (57.6 mm beam width at isocenter). Due to the diverging nature of the x-ray beam and the varying thicknesses of the BTF along each fan angle 5, the maximum thickness deviation between the two profiles for the Tube B head filter was 0.20 mm. The body BTF thickness profiles for both tubes were in good agreement with published results utilizing a different method2; no published head BTF was available for comparison.

RESULTS

Table 1 shows the maximum differences in mm Al at 80 kVp and 120 kVp acquisitions with (a) Tube A head BTF, (b) Tube A body BTF, (c) Tube B head BTF, and (d) Tube B body BTF.

Table 2 shows the maximum differences for each of the filters at the two energies.

CONCLUSIONS

The COBRA method + HVL measurements has been shown to produce BTF profiles in good agreement with other methods. In our study, the fan angle range investigated was restricted to a FOV occupied by an average patient. The resulting derived BTF profiles obtained at different energies (80 kVp & 120 kVp) were in close agreement with each other and with results obtained by Yang et al1 for the body BTF. No published head BTF was available for comparison.