Purpose: MDCT beam-shaping filters modulate X-ray intensity across the fan beam, reducing patients' skin dose while homogenizing detector statistics. A simple theoretical model for calculating beam-shaping filter geometry has been developed; and for calculated attenuation profiles Monte-Carlo (MC) simulated transmission spectra have been compared to measured X-ray spectra.

Methods: Based on the assumption that X-ray intensity after transmission through a given set of a beam-shaping filter and a cylindrical object of homogeneous composition is equal for all fan angles, a theoretical beam-shaping filter geometry has been calculated. For a set of fan angles (0°–21° relative to central ray of the fan), transmission spectra were simulated for calculated filter geometry using a Geant4 MC simulation. Simulated spectra have been compared to fan-angle dependent measurements of MDCT X-ray spectra (120kVp) acquired using a Compton spectrometer. Additionally, the initial assumption of equalized X-ray intensity after beam transmission through a set of shaping filter and homogeneous cylindrical phantom was checked by simulating resulting detector signal.

Results: Comparison of measured transmission spectra to those resulting from simulation of a beam-shaping filter geometry estimated using the proposed theoretical model yields maximum differences below ±2.0% for all fan angles. K-lines of simulated and measured spectra match well and are in agreement with theoretical values for tungsten anodes. Measured and simulated filter transmission and mean X-ray energy after filter passage are also in good agreement. For the modeled filter geometry the initial assumption of signal homogenization could be validated through simulation.

Conclusions: Comparison of measured transmission spectra to those simulated for a beam-shaping filter geometry estimated using the proposed theoretical model reveals excellent qualitative and quantitative agreement. Thus the proposed method can be used for calculating reliable estimates of MDCT beam-shaping filter geometry instead of having to rely on manufacturers' data or resort to time-consuming measurements.

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