Purpose: As an emerging x-ray tomographic imaging method for preclinical and eventually clinical applications, the grating-based x-ray differential phase contrast (DPC) CT is drawing increasing interest for its research and development. It has been hoped that the potential $S(k)$ in the DPC-CT can be significantly larger than its counterpart in the conventional attenuation-based CT. We investigate the DPC-CT's NEQ(k) under the ideal observer framework in this study.

Methods: In general, the signal and noise transfer properties of an imaging system is determined by its modulation transfer function MTF(k) and noise power spectrum NPS(k), respectively, which jointly characterize the spectrum of noise equivalent quanta NEQ(k). The eventual performance of an imaging method is determined by its detectability index or squares signal-to-noise ratio defined as an integration of the product of inputting signal, i.e., the contrast between the object to be imaged and the background, fed into the system to implement the imaging method and the system’s NEQ(k). Through theoretical analysis, modeling, simulation, we derive and evaluate the NEQ(k) of the DPC-CT and compare it with that of the conventional CT.

Results: Preliminary data show that, there exist only a modest difference in the signal transfer property MTF(k) between the DPC-CT and conventional CT. However, owing to an adoption of the Hilbert filtering for image reconstruction, the noise transfer property NPS(k) of the DPC-CT differs drastically from that of the conventional CT, which results in a dramatic difference in NEQ(k) between the DPC-CT and conventional CT.

Conclusions: Based on an in-depth investigation, the potential imaging performance of the grating-based DPC-CT in comparison to the conventional attenuation-based CT can be fully understood and appreciated, providing insightful guidelines on the design and performance optimization of DPC-CT as a new imaging technology.

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