Purpose: To demonstrate that megavoltage cone beam CT (MVCBCT) image quality can be significantly improved without increasing imaging dose or reducing spatial resolution for both head- and pelvis-sized volumes. The improvement is achieved with the combination of an imaging beam line (IBL) with a low atomic number electron target and a novel sintered pixelated array (SPA) detector.

Methods: Three Siemens Oncor linear accelerators were equipped with an IBL+SPA system, an IBL system with a conventional Kodak Lanex Fast B scintillator (IBL+LFB), and a 6 MV treatment beam line system with an LFB (TBL+LFB). Head- and pelvis-sized phantom images were acquired with all three systems at imaging doses ranging from 2-60 cGy. Contrast to noise ratio (CNR) and modulation transfer function (MTF) were calculated from the phantom images. Head and neck, prostate, and lung cancer patients were imaged with the three imaging systems at doses ranging from 2-15 cGy.

Results: For head- and pelvis-sized phantom images acquired at 5 cGy or above, the CNR average percentage increases for imaging system upgrades from TBL+LFB to IBL+LFB to IBL+SPA were 52% ($p < 1E-7$) and 42% ($p < 1E-6$), respectively. The MTFs do not change with imaging system by statistically significant percentages. Soft tissue contrast is generally more easily differentiated on IBL+SPA images than TBL+LFB and IBL+LFB in the patient images.

Conclusions: Since CNR scales with the square root of imaging dose, each step in the TBL+LFB to IBL+LFB to IBL+SPA upgrade halves the imaging dose required to obtain a given CNR. No statistically significant change in spatial resolution was observed with any upgrade, suggesting that the pixelation of the SPA prevents a loss in spatial resolution. IBL+SPA patient image quality was always better than that of the TBL+LFB system and as good as or better than that of the IBL+LFB system.

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