

The study of dual-energy computed tomography as a technique for measuring bone mineral density

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A prototype dual-energy CT scanner (Siemens DR-3) was evaluated for quantitative accuracy and noise properties. Basis material decomposition based on theoretical calculations was compared to that based on measured attenuation data showing inaccuracies in the calculations at large attenuator thicknesses. Measurements of scattered radiation in the detectors showed that the inaccuracies in the attenuation calculations were caused by scattered radiation and enabled a scatter correction to be applied to the basis material decomposition procedure improving the CT-number accuracy. The theoretical aspects of noise correlation in dual-energy images were studied and filters applied which reduced correlated noise but caused significant edge artifacts. An iterative reconstruction technique was developed that provided CT images having reduced noise compared to those reconstructed using filtered back-projection. This was achieved by accounting for the differences in expected variances among projections, assigning smaller weighting factors to projections with poorer precision. The iterative technique was a least squares optimization by the method of conjugate gradients. Noise reduction without loss of spatial resolution or quantitative accuracy or the introduction of image artifacts was demonstrated with the reconstruction of measured phantom data. Dual-energy CT was applied to the measurement of bone mineral density. The measured mineral density was compared to the mechanical strength of canine bones. The sensitivity of the technique was compared to the level of bone loss in the presence of disease by scanning vertebrae from oophorectomized monkeys. A limited number of human subjects were also scanned as part of an effort to determine the range of normal bone density values and to determine the most effective protocol for assessment of bone mineral density in the spine.