Purpose: There is an increasing need to develop fast and accurate dose calculation algorithms for kilovoltage (kV) x-rays. This study describes a new model-based method and presents initial results of its calculation accuracy.

Methods: The new approach calculates the radiation dose to patients by calculating the dose to water-like media first. This is done by assuming all voxels in a patient CT data set are water, but with densities scaled according to a CT-number-to-density calibration. The dose distribution to water-like media with physical density considered is calculated by summation of pencil beam percent depth-dose curves, considering the incident x-ray fluence profiles and empirical x-ray scatter factors. The beam modeling parameters were obtained by the Monte Carlo method. The final dose distribution calculated for the actual physical media is obtained using medium-dependent correction (MDC) factors. The MDC factor at a voxel is expressed as a function of an intermediate quantity, the effective bone depth, which is calculated from patient CT data. The accuracy of this new approach was tested for calculating the dose resulting from a kV cone-beam CT scan by comparing to Monte Carlo calculations.

Results: The calculated dose using the new approach was shown to agree with Monte Carlo within 3% for the mean dose to bone, and within 1% for the mean dose to soft-tissue. The dose to bone was on the order of 2-3 times the dose to soft-tissue. The computation time of the new approach is significantly less than Monte Carlo.

Conclusions: The new approach was shown to be very promising and has potential to extend current model-based dose calculation algorithms to the kV energy range.