AbstractID: 8847 Title: Bone Models for Kilo-Voltage X-Ray Monte Carlo Simulations

Purpose:
The single-bone tissue model commonly used in radiation therapy may be over simplified. Experiments and simulations have shown that in mega-voltage x-ray dose computation this model can cause errors of up to 10%. In the kilo-voltage range a much higher error is expected because of the larger variation of the mass attenuation coefficients of different bone tissues. This error could produce significant errors in dose computation and potentially result in noticeable biological effect. A more effective bone model is therefore needed.

Method and Materials:
A model containing multiple bone compositions can be formulated to more accurately represent the distribution of attenuations found in vivo. Based on the observation that bone calcium and phosphorus contents are strongly correlated with the bone density, we propose a methodology in which the interpolated compositions of these 2 elements and the averaged compositions of other 10 major elements are assigned to a model bone based on its density. A series of 24 model bones was generated that covers the bone density range 1.1 to 2 gram/cm^3. The error of primary photon total energy released per unit mass (terma) was used to evaluate the models. Photon-tissue interaction cross-sections are calculated and Monte Carlo simulation was performed to estimate the dose deposition error.

Results:
In the kilo-voltage range, if a bone is assigned with the correct density but an inaccurate composition, the terma error by the single-bone model can reach 25%. The 24-bone model reduces this error to below 0.5%. A simulation shows that in a 120 kVp x-ray radiation to a mouse brain, the skull dose predicted by the single-bone model can be 2.13 times that by the 24-bone model.

Conclusion:
A multiple-bone model is proposed. Use of this model should significantly improve dose computation accuracy, especially in kilo-voltage x-ray spectrum range.