LETTER TO THE EDITOR

Deriving Hounsfield units from the grey scale of a CBCT?

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I should like to compliment P Mah, TE Reeves and WD McDavid on their comprehensive paper “Deriving Hounsfield units using grey levels in cone beam computed tomography”, in the September 2010 issue of DMFR.¹ As the authors note, there has been a certain criticism of the accuracy of Hounsfield numbers from cone beam CT scanners, but relatively little quantitative study. I should therefore like to draw the authors’ attention to the paper from Bryant JA et al,² which has several findings on the absolute accuracy of Hounsfield numbers that are complementary to the authors’ paper.

Mah et al use a phantom with a water container that is quasi-uniform in the vertical direction in terms of the mass of material per horizontal, cross-sectional slice, largely because the water dominates. In our paper, using an i-CAT Classic, we found that the grey scale value varied linearly with the total mass in the slice and we strongly suspect that this is a universal result. I would invite Mah et al to take some additional containers with smaller diameters to check this dependence on mass. We found error in CT number as a function of the mass in a slice 0.4 mm thick:

$$\Delta(\text{CTno.}) = -98 \times (\text{mass [gram]} - 5) [\text{HU}]$$

Knowing, from Mah et al, that many materials scale linearly with the attenuation coefficient for a given mass per slice and that this is true in a wide range of machines, a universal correction algorithm may be possible, at least for biological substances. Our paper

proposed a trial algorithm for the i-CAT Classic that took into account the variation of mass in a slice according to the vertical position in the head.

Furthermore, if, instead of averaging the grey scale values, a detailed plot is made, it becomes evident that the noise is far from insignificant. We obtained a noise level in signal as a function of mass in a slice 0.4 mm thick:

$$\text{Noise} = \pm(50 + 10 \times \text{mass [gram]}) [\text{HU}]$$

This noise greatly reduces the ability to detect fine structures with small grey scale differences. Our paper also addresses some higher order distortions, but these are less intrusive than the zero order error (average values) and the basic noise.

It is of interest to note that the first equation for the CT number error contains the term (mass [gram] - 5). In other words, the i-CAT Classic gives approximately the correct Hounsfield value when the mass is 5 g in a 0.4 mm thick slice. An adult human head has on average 7 g per 0.4 mm slice of which 5 g are in the field of view (FOV) and 2 g belong to the back of the head outside the FOV.

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References

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2. Bryant JA, Drage NA, Richmond S. Study of the scan uniformity from an i-CAT cone-beam CT dental imaging system. *Dentomaxillofac Radiol* 2008; **37**: 365–374.