Correspondence

Quantitative computed tomography

To the Editor:

In a recent paper, Alho et al. (1989) describe their measurements of cadaver femora comparing bone density and volume at several sites using quantitative computed tomography, and relating these values to measurements of strength of the bone under axial loading to fracture. Their measures (Table 1) were made using a system without calibration phantoms, and both cortical and trabecular bone were evaluated at the femoral head (trabecular bone) and neck (trabecular and cortical bone), the diaphysis (cortical bone) and the distal condyles (trabecular bone). The results obtained suggest site differences for both cortical and trabecular bone densities.

I write to inject a word of caution with respect to the results presented by Alho et al. and their interpretation.

A recent paper from this laboratory (Hangartner et al. 1987) discusses the errors inherent in computed tomography of bone and explicitly illustrates the particular problem of quantitative evaluation of cortical bone of varying thickness.

The differences in cortical bone density reported by Alho et al. between the cervicotrochanteric and diaphyseal regions (50 percent higher cortical density at the diaphysis), and in trabecular density at the cervical and condylar regions (condylar = 0.75 x cervical density), would be expected as artifacts resulting from the technology employed, given the geometry (i.e., thickness differences at the sites measured) of the femur.

We are also carrying out a study in which cortical and trabecular bone densities are measured at different sites in cadaver femora using our special purpose, high-resolution computed tomography systems; to this time, we have found no differences in absolute densities for either cortical or trabecular bone at different measurement sites.

A greater knowledge about the variation of cortical and trabecular bone densities throughout the femur, in health and in disease, is important. However, the application of an inappropriate technology to such measures can lead to erroneous conclusions.

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To the Editor:

We appreciate the comments of Dr. Overton, who raises two methodical issues: the necessity of using calibration phantoms and the systematic error related to compact bone surrounding the (trabecular or cortical) bone to be measured.

Opinions differ concerning the need of simultaneous calibration systems. The theory of such a system is to subject a calibration phantom and the measured object to identical errors. However, placing the calibration phantom outside the body, while the measured object is inside the body, gives different beam-hardening effects on the two. We have recently concluded a study showing that this has a substantial effect on the correctness of the calibrated values. This accords with the results of Hangartner et al. (1987), shown in their Table 1, with a 6 percent reduction in CT numbers when an object is measured in a small and a medium large body. The calibrated values showed a similar discrepancy of 5 percent. Our studies indicate that our measurements have a high precision and that the equipment has good stability; therefore, we have omitted special calibrations. Especially, we could see no point in using any external calibration phantoms in a cadaver bone study where all the soft parts were removed.

In our article, we repeatedly call our HU values approximations. There is no doubt that varying compact-bone thickness has an effect on the density readings inside as Hangartner and coworkers so nicely showed. However, as we stated and as our Figure 1 shows, the cortex in the femoral head and mid-condyle is so thin that it cannot be measured separately. In such conditions, we feel secure that trabecular bone density is distinctly higher in the femoral head than in the condyles. Figure 1 also shows that the cortex at the measured level of the cervicotrochanteric area is clearly thicker than the condylar cortex. In spite of the augmenting effect of a thicker compact bone, the readings inside the cervical cortex are lower than the condylar readings. Another matter, of course, is reading on a macro instead of a micro level. The trabecular bone unit thicknesses may be similar with their varying numbers giving varying density values.

Concerning the cortical bone densities, Dr. Overton suggests that a 50 percent difference in CT numbers, approximately 800 CT numbers, can be explained by the difference in bone geometry and that the density difference is an artifact. Our data suggest that an error in the order of 10–30 CT numbers may be more correct.

We thank Dr. Overton for his comments, which do not, however, invalidate our conclusions.

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References

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