Bone Mineral Measurements: A New Clinical Tool

Photon absorptiometry by single- or dual-energy techniques has evolved as a powerful method to estimate bone mineral content in selected bones or of the entire skeleton. Though it has been known for many years that bone mineralization changes with age and in disease, it is only in recent years that this change can be monitored accurately and cost effectively for the routine diagnosis and management of bone disease.

As with other laboratory techniques, photon absorptiometry has been refined with time. When first introduced in 1963 by Cameron and Sorensen (*1*), it was envisioned as a simple and relatively inexpensive method to assess bone mineral content. The radius served as a convenient sampling site for the entire skeleton as well as for bone mineral estimation in spine and hip. (The latter sampling sites are of particular interest, because they are frequent locations for nontraumatic compression fractures.) We realized a decade later that single-photon absorptiometry on the radius could be useful for epidemiological studies and clinical research in metabolic bone disease. The method, however, lacked sensitivity for individual case diagnosis and for patient management decisions. The necessary sensitivity can only be achieved through measurements on trabecular bone sites, a point well illustrated by the article of Mazess et al. (*2*) in this issue of the *Journal*. The introduction of dual-photon absorptiometry, which was first developed by Roos et al. (*3*) and was further evolved in this country by R.B. Mazess and his group (*4–6*), solved this dilemma. Dual-photon absorptiometry can now be used for measurement of bone mineral in the total skeleton, the lumbar spine, the hip, and, as Mazess describes, also in regions of interest in other sites of the skeleton. Details of the procedures for single- and dual-photon absorptiometry and results from clinical applications have been summarized recently (*7*).

Since bone mineral measurements of almost any skeletal site can be performed, the selection of the most appropriate site for a given medical problem is an important issue. A few considerations are offered. In clinical practice, bone mineral measurements by photon absorptiometry are performed to assess cortical or trabecular bone loss resulting from accelerated bone resorption or decreased bone formation, to measure or predict total body calcium, and to provide information about fracture risk at a specific skeletal site. The validity of this information is based on the high correlation between measured bone mineral in vivo and ashed bone weight (*8*) and on the observation that the breaking strength of bone is linearly related to its mineral content (*9–10*). The relationship between abnormal bone remodelling and measured bone mineral is easy to understand. Absorptiometry assesses the amount of bone mineral present at the time of the measurement, which reflects present and past bone changes, and is, therefore, related to the severity as well as the duration of bone loss. Bone biopsy assesses more specific details of bone remodelling. The relationship between fracture site and bone mineral is more complex. Decreased strength of bone and increased susceptibility to fracture are related, but not equivalent, to the quantity of bone mineral in both trabecular and cortical bone. Geometric changes in compact bone with aging, predominant loss of either cortical or trabecular bone, and the occurrence of microfractures in cortical bone can alter the relationship between breaking strength and bone mineral content. Nevertheless, in laboratory and epidemiological studies bone mineral measurements have been used successfully to predict fracture thresholds for bones.

The skeleton is 80% cortical bone and 20% trabecular bone, the latter located mainly in the axial skeleton. Because of its greater surface area, trabecular bone is metabolically more active and thus more likely to change. Physiological bone loss as well as bone loss from disease ultimately affects the entire skeleton. There are, however, differences in bone loss patterns in different bones, and bone loss occurs at different rates on different bone surfaces, even within the same bone. Further-

more, it appears that these patterns vary in prominence in different individuals, and the variations influence fracture patterns in different diseases and must be considered when measurements are interpreted.

At this time, with respect to clinical application, dual absorptiometry of the spine (trabecular bone site) and single absorptiometry of the mid-radius (cortical bone site) are most widely used to measure bone mineral content (*11–12*). Data on bone mineral of the hip are accumulating in the literature and are of potential clinical interest (*13*). Information on the total skeletal bone mineral for routine management of patients awaits further evaluation. It must also be proven that in the spine or hip, bone mineral can be determined with equal accuracy and reproducibility from total skeletal images by the region-of-interest approach as it can now be done from dedicated measurements alone.

The radiation dose, as determined by thermoluminescent dosimetry (TLD) on phantoms and patients, depends on the strength of the source and beam characteristics, and it ranges from 5–15 mrad (0.05–0.15 mGy) peak skin dose at beam entrance for dual-photon absorptiometry to about 5 mrad (0.05 mGy) for single-photon absorptiometry of the radius (*8*). Total-body or limited-neutron activation analysis and quantitative computed x-ray tomography are alternative methods when the facilities are available.

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