Henry Ford Hospital Medical Journal

Volume 31 | Number 4 Article 4

12-1983

Assessment of Trabecular Bone Status

A. M. Parfitt

Henry Ford Hosp Med J
Vol 31, No 4, 1983

Assessment of Trabecular Bone Status

A.M. Parfitt, MBB Chir*

Ed. Note - This overview was originally presented at the International Symposium on Clinical Disorders of Bone and Mineral Metabolism, May 9-13, 1983. The following list indicates the presentations given in this session at the Symposium and the contents of the corresponding chapter in the Proceedings of the Symposium published by Excerpta Medica. The numbers in parentheses refer to pages in this volume. Complete information about the contents of the Proceedings can be found at the back of this issue.

Problems in measurement of trabecular bone. R.B. Mazess (30)

Dual-photon absorptiometry: Clinical considerations. H.W. Wahner, W.L. Dunn, K.P. Offord, and B.L. Riggs (34)

Quantitative computed tomography for vertebral mineral determination. H.K. Genant, C.E. Cann, D.P. Boyd, F.O. Kolb, B. Ettinger, and G.S. Gordan (40)

Clinical application of peripheral computed tomography. P. Ruegsegger and M. Dambacher (48)

Comparison of trabecular bone density at axial and peripheral sites using computed tomography. T.N. Hangartner, T.R. Overton, and W.M. Rigal (54)

Comparison of dual photon absorptiometry and quantitative computed tomography of the lumbar spine in the same subjects. M.R. Powell, F.O. Kolb, H.K. Genant, C.E. Cann, and B.G. Stebler (58)

At our last clinical symposium in 1972 (1), the assessment of cortical bone by radiogrammetry and by single energy photon absorptiometry was discussed in detail. The uses and limitations of these methods are now well established and have provided an extensive body of data on age-related loss of cortical bone. We now need similar data for trabecular bone because of many differences between these two types (see Table).

The study of trabecular bone is attended by many more technical problems than the study of cortical bone. Some of the methods for measuring trabecular bone are given below:

Histomorphometry (ilium, vertebra)
Photodensitometry (phalanges, vertebrae)
Compton scatter (calcaneum)
Single energy photon absorptiometry: single path (radius)
Single energy photon absorptiometry: multi-path (radius)
Partial body neutron activation (trunk)
Dual energy photon absorptiometry (spine, femur, whole body)
Computed tomography (spine, distal radius, distal tibia)

Although histomorphometry of trabecular bone is useful in population studies, it is a cumbersome, inaccurate method for determining trabecular bone mass in individual subjects. Photodensitometry using an aluminum or potassium phosphate stepwedge is subject to several sources of error, but it needs no capital investment and could be used more widely (4). The description of the Compton scatter technique at the last meeting aroused much excitement, but a decade later a clinically useful procedure has still not been perfected (5). Single energy photon absorptiometry at the distal measurement site in

*Department of Internal Medicine, Bone and Mineral Metabolism Division, Henry Ford Hospital
Address reprint requests to Dr. Parfitt, Bone and Mineral Metabolism Division, Henry Ford Hospital, 2799 W Grand Blvd, Detroit, MI 48202.

TABLE

Comparison of Cortical and Trabecular Bone

	Cortical	Trabecular
Envelopes	Two	One
Proximity to bone marrow	Variable	Close
Surface/volume	Low	High
Turnover	Low	High
Treatment response	Slow	Rapid
Mineral reservoir	Yes	No*(!)
Relationship of amount to age	Curvilinear	Varies with method
Effect of menopause	Acceleration	Varies with method
Fractures	Long bones	Vertebrae

*In humans, a temporary physiologic need for bone mineral during growth, pregnancy, and lactation is met by increased cortical porosity (2), and the most important long-term response to increased parathyroid hormone secretion is cortical thinning (3).

the radius is frequently, but erroneously, believed to provide information on trabecular bone (6). However, use of single path instruments such as the Norland-Cameron reveals much less trabecular bone at this site than is commonly supposed, and the trabecular bone found is metabolically inert and contributes little to the observed changes. The situation is slightly better with instruments capable of scanning at multiple levels that can get closer to the active trabecular bone in the metaphysis (7). With partial body neutron activation, it is possible to measure the axial skeleton separately from the appendicular skeleton. The measurement includes a higher proportion of trabecular bone than total body calcium determination (8). The last two methods are currently receiving most attention. In the proceedings of our last meeting, dual energy photon absorptiometry (DPA) occupied less than half a page in a 700-page book, and quantitative computed tomography (QCT) had not been applied to bone at all.

Mazess (pp. 30 ff.) further described the peculiarities of trabecular bone, including its variable response to disease and treatment at different anatomic locations and consequent poorer site-to-site correlation than found in cortical bone. He once more drew attention to the problems caused by variable marrow composition, particularly for single energy QCT. Some of the surprisingly rapid loss reported after oophorectomy could in part be due to increase in marrow fat. Wahner, et al (pp. 34 ff.) reviewed the Mayo Clinic experience with DPA and described the relative immunity of this technique to changes in marrow fat. He also confirmed the apparent linear decline in spinal bone density with age and failure to observe a postmenopausal acceleration in bone loss with cross-sectional data. This may reflect in part the contribution of cortical bone in the vertebral appendages and probable increase in calcium deposition in paraspinal soft tissues and aorta with age. DPA of the spine discriminates between persons with and without vertebral compression fracture much better than single energy PA of the radius.

Genant, et al (pp. 40 ff.) reviewed the advantages of QCT for selective examination of trabecular bone and described how recent technical advances have reduced the error due to variable marrow fat. In contrast to DPA, a postmenopausal acceleration of trabecular bone loss is observed with QCT. Discrimination between persons with and without compression fracture appeared less satisfactory than with DPA, but this may have been the result of including some patients with wedging but without compression of a vertebra. However, as with DPA, discrimination is much better than with measurements of peripheral cortical bone.

Ruegsegger and Dambacher (pp. 48 ff.) described the application of QCT to trabecular bone of the extremities, particularly the distal radius and distal tibia. This technique has the highest precision of all the methods discussed, allowing the demonstration for the first time that bone loss in some patients occurs in abrupt steps rather than continuously. Because of its high precision, the technique is also ideally suited for monitoring the short-term response to a large number of potential therapeutic agents that could be used in accordance with the Activation-Depress-Free-Repeat (ADFT) concept of Frost. Using a similar method, Hangartner (pp. 54 ff.) observed a significant correlation between trabecular bone density measured by QCT in the distal radius and in the spine but with a prediction error of about 20%. The implication of this new approach remains to be explored in detail. Finally, Powell, et al (pp. 58 ff.) reported a rather low correlation between QCT and DPA measurements in the same subjects, although QCT correlated somewhat better than DPA with a semi-quantitative fracture index.

A great deal of progress has been made in the noninvasive study of trabecular bone in the last ten years. There is still controversy about the size of the error due to variable marrow fat and about the success of different techniques in coping with this error. More studies are needed directly comparing the two major techniques of DPA and QCT in the same subjects, particularly serial measurements by both methods. Further improvement in both precision and accuracy is likely, but this must not be made an excuse for curtailing the duration of therapeutic studies, which is dictated by the biological charac-

teristics of the remodeling system and not by technical factors in the methods of measurement (9).

Also, much more is involved in the study of trabecular bone than simply measuring its amount. The complex three-dimensional structure of this tissue, which is clinically important for several reasons, is accessible to high resolution CT applied to iliac bone samples (10). Perhaps in another decade instrumental resolution will increase to the extent that similar information can be obtained from the intact patient, but this will probably require the application to bone of even newer methods such as nuclear magnetic resonance.

References

1. Frame B, Parfitt M, Duncan H, eds. Clinical aspects of metabolic bone disease. Amsterdam: Excerpta Medica, 1973.
2. Parfitt AM. Integration of skeletal and mineral homeostasis. In: DeLuca HF, Frost H, Jee W, Johnston C, Parfitt AM, eds. Osteoporosis: Recent advances in pathogenesis and treatment. Baltimore: University Park Press, 1981:115-25.
3. Kleerekoper M, Villanueva AR, Mathews CHE, Rao DS, Pumo B, Parfitt AM. PTH-mediated bone loss in primary and secondary hyperparathyroidism. In: Frame B, Potts JT, eds. Clinical disorders of bone and mineral metabolism. Amsterdam: Excerpta Medica, 1983.
4. Colbert C, Bachtell RS. Radiographic absorptiometry (photodensitometry). In: SH Cohn, ed. Non-invasive measurements of bone mass and their clinical applications. West Palm Beach: CRC Press, 1981:58-84.
5. Webber CE. Compton scattering methods. In: SH Cohn, ed. Non-invasive measurements of bone mass and their clinical applications. West Palm Beach: CRC Press, 1981:101-20.
6. Hahn TJ, Boisseau VC, Avioli. Effect of chronic corticosteroid administration on diaphyseal and metaphyseal bone mass. J Clin Endocrinol Metabol 1974;39:274.
7. Christensen MS, Christiansen C, Naestoft J, McNair P, Transbol I. Normalization of bone mineral content to height, weight and lead body mass: Implications for clinical use. Calcif Tiss Int 1981;33:5-8.
8. Harrison JE, McNeill KG, Hitchman AJ, Britt BA. Invest Radiol 1979;14:27-34.
9. Parfitt AM. The morphologic basis of bone mineral measurements: Transient and steady state effects of treatment in osteoporosis. Editorial. Mineral & Electrolyte Metab 1980;4:273-87.
10. Feldkamp LA, Kleerekoper M, Kress JW, Freeling R, Mathews CHE, Parfitt AM. Abst. Calcif Tiss Int (in press).