

Volumetric and projective bone mineral density

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Abstract

Projectional bone mineral density measurement so far used extensively in radiogrammetry and single and dual source absorptiometry is confronted with a serious limitation for the accurate evaluation of true density artifactually providing higher values along with the increase of body size and bone depth on account of the omission of one dimension. Computed tomography is capable of measuring true volumetric density and also accomplishes a separate measurement of trabecular and cortical bone especially on application to the distal and mid-radius with abundant cortical bone in peripheral computed tomography (pQCT). New lines of information may be obtained by such separate trabecular and cortical bone measurement in decreases of bone density due to various causes, estrogen withdrawal, corticosteroid, diabetes mellitus, renal failure, etc. Dynamic analysis of the result of pQCT may also make it possible to assess bone strength and resistance to fracture.

Keywords: Dual X-ray Absorptiometry (DXA), Peripheral Computed Tomography (pQCT), Trabecular Bone, Cortical Bone, Peak Bone Mass

Introduction

Non-invasive bone mineral assessments starting from measurement of two-dimensional roentgenograms^{1,2} had difficulties to overcome the limitations on account of the projectional nature of the measurement technique over its development through single and dual photon absorptiometry and single and dual energy X-ray absorptiometry³⁻⁵.

To call projectional density bone mineral density is a misnomer according to the traditional use of the word density in physics. Quantitative computed tomography, a three-dimensional volumetric measurement, made it possible to assess bone mineral density in its true physical sense^{6,7}.

Applied at first on the vertebral body using phantoms for direct comparison, quantitative computed tomography extended its application to separate measurement of trabecular and cortical bone and dynamic estimation of bone strength on its application on the distal and middle radius with wider cortex.

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Projectional "bone mineral density" and true volumetric density measured by quantitative computed tomography (QCT)

Density is defined by mass per volume in physics, to be expressed as mass/length³. Projectional density used in radiogrammetry and single and dual source absorptiometry expressed as mass/length² is evidently different from the true volumetric density mass/length³ expressed in units of g/cm³. Though such projectional approach of bone measurement presents with no problem for bone mass assessment, it is quite misleading as the expression of density. The widely used dual energy X-ray absorptiometry (DXA), the gold standard method for the evaluation of the drug effect on osteoporosis, always gives higher values in subjects with larger body frame and bone depth, males over females, Caucasians over Asians and older children over younger ones. How much of such difference in projectional density is real and how much is artifactual due to body size or bone depth difference remains to be clarified.

True volumetric bone density measurement of the trabecular bone of the vertebral body was achieved by quantitative computed tomography. Attempts were made to measure the cortical bone of the vertebral body despite technical difficulty due to thin cortex⁸. Peripheral computed tomography applied on the distal radius made it

Accepted 15 October 2001