

Opinion

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Dual X-Ray Photon Absorptiometry: Beyond the Bone Quantity?



F M Ulivieri*

Fondazione Irccs Cà Granda Policlinico, Italy

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***Corresponding author:** F M Ulivieri, Fondazione Irccs Cà Granda Policlinico, Bone Metabolic Unit, Via FSforza 35, 20122 Milan, Italy,
Tel: +300255033529; Email: ulivieri@gmail.com

Opinion

Osteoporosis is characterized by low bone mass and micro-architectural deterioration, with a consequent increase in bone fragility [1]. Bone strength impairment leads to an increased risk of fracture, as strength reflects the integration of bone quantity (bone mineral density, BMD) and bone quality [2]. Common sites of osteoporotic fractures are spine, hip, distal forearm and proximal humerus. These fractures determine high rates of disability and mortality: 50% of fracture-related deaths in women are due to hip fractures, 28% to clinical vertebral fractures and 22% to other fractures [1]. Twenty percent of hip fractured patients, die within the following year and 20% require permanent nursing home care [3,4]. Vertebral fractures are the most frequent fractures in osteoporotic patients, and are associated with substantial disability due to compromised spine dynamics and static biomechanics. Furthermore, their number and severity are related to an exponential increase of subsequent fractures [5].

The WHO gold standard method for the diagnosis of osteoporosis is the dual energy X-ray absorptiometry (DXA) [6], that allows to quantify BMD [7] that is directly correlated with an increase in fracture risk [1]. However, a relevant number of fragility fractures occur in the range of normal or slightly reduced BMD values [8], meaning that also qualitative aspects of bone, like bone architecture and bone geometry, play a role [9]. These bone structure aspects are, however, investigated by micro CT and histomorphometry and necessitate an invasive approach with a biopsy, usual taken at the iliac crest, not the typical site of fragility fractures.

New DXA tools recently developed, namely trabecular bone score (TBS) and hip structural analysis (HSA), obtained during DXA, can supply in formations about bone structure of spine and femur, respectively, in a not invasive way.

The first cited new DXA tools is the trabecular bone score (TBS), a gray-level textural measure that can be extracted from the 2-dimensional lumbar spine DXA image to estimate trabecular microstructure. TBS provides in-formations that

are not captured by the standard BMD measurement [10]. The relationship between TBS texture and 3-dimensional micro-architecture parameters was documented by several ex vivo studies that reported significant correlations with the bone histology parameters defined by Parfitt (trabecular space and number, connective density); these correlations are independent from areal bone mineral density [11-15]. An elevated TBS value correlates with better skeletal texture, reflecting a better micro architecture. Recent studies demonstrated that TBS predicts fracture risk partially independently from BMD in primary and secondary osteoporosis and after pharmacological treatment [16-20]. However, nowadays a debate arouses about what TBS really represents and particularly about its true relation to vertebral strength [21,22].

TBS has been investigated also in the monitoring of pharmacological treatment of osteoporosis with evidence that it increases particularly with anabolic therapy, but the moderate entity of the amount, close to or even below the least significant change (LSC) of the measurement, does not suggest a use in clinical practice where physicians treat the single patient [23]. Noticeably, no data are available regarding changes of TBS and HSA after longer periods of treatment and no studies have investigated the relationship between TBS and HSA changes after anabolic agents and the reduction of fracture incidence, which is the real clinical goal of every pharmacological treatment of osteoporosis. It remains, therefore, an open question, if such a small increase in TBS, close to the LSC, results in an amelioration of bone quality able to determine a reduction of fracture rate [23].

The second cited DXA tools, HSA, similarly to BMD, was shown to relate independently to hip fracture risk [24]. The concentration of loading forces (stresses) is a function of bending moments and cross sectional geometry. Based on the principle described by Martin and Burr [25], a specific program for bone densitometry was developed, named Hip Structural Analysis (HSA), that derives the cross sectional geometry from images acquired by DXA. The main geometrical parameters, measured

at narrow neck (NN), intertrochanter (IT) and femoral shaft (FS), are the bone surface area in the cross section (CSA) and the section modulus (Z), which are inversely related to maximum stresses due to axial and bending loads, respectively [26,27]. CSA is an index of resistance to axially directed compressive loads. Z is computed from the cross sectional moment of inertia (CSMI), which reflects the flexural strength being an index of rigidity. The ratio between the radius and the average cortical thickness provides a stability index of the cortex under compressive and bending loads (buckling ratio, BR).

Some works were published about HSA in osteoporosis and about bone quality variations after its pharmacological treatment [28]. After therapy, particularly with bone formation agents, changes in bone axial and bending strength and in cortical thickness are expected [23].

However, literatures to date do not allow to consider HSA as a reliable measure to predict fracture risk and to monitor pharmacological treatment for osteoporosis [28].

TBS and HSA are able to give additional information about bone strength that it is not supplied by BMD alone, although there is not unanimity of views, particularly about HSA. These parameters allow clinicians to better classify patients affected by a fragility fracture and to predict the risk of future fractures. TBS and HSA increase with anabolic therapy, but the moderate entity of the amount, close to or even below the LSC of the measurement, does not suggest a use in clinical practice where physicians treat the single patient.

Surely TBS and HSA have a special merit: having supplied to DXA not only an utility to the measurement of bone quantity, but even more for inquiring bone quality. Thus opening a new path to the promising evolutions of the dual X-ray photon absorptiometry.

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