Trabecular Bone Score

A New DXA–Derived Measurement for Fracture Risk Assessment

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KEYWORDS

• Trabecular bone score • FRAX • Osteoporosis • Fracture risk • Bone mineral density

KEY POINTS

- Trabecular bone score (TBS) is a textural index based on evaluating pixel gray-level variations in the lumbar spine dual-energy x-ray absorptiometry (DXA) image.
- TBS predicts the risk of major osteoporotic fracture (MOF) and hip fracture in women and men greater than 40 to 50 years of age.
- TBS can be used to adjust World Health Organization Fracture Risk Assessment Tool (FRAX) probability of fracture in postmenopausal women and older men, assisting in treatment decisions in clinical practice.
- Improvements in TBS due to diverse antiosteoporotic agents tend to be much smaller than those observed in lumbar spine bone mineral density (BMD).

INTRODUCTION

Osteoporosis is characterized by compromised bone strength, predisposing to an increased risk of fracture.[1] An accepted operational definition for osteoporosis in postmenopausal women or in men age 50 years and older is when BMD by DXA is 2.5 or more SDs below the average young reference value (ie, a T score ≤ -2.5).[2,3] Low BMD by DXA is a strong predictor of fracture risk: for each SD decrease in BMD, there is a 1.4-fold to 2.6-fold increase in the risk of fracture.[4,5] Most individuals with fragility fractures have BMD values that do not fall within the osteoporotic range.[6,7] Therefore, the identification of other skeletal and extraskeletal risk factors that contribute to overall fracture risk can be used to better select patients for treatment.

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Readily assessable clinical risk factors, such as age, previous fragility fracture, parental history of hip fracture, smoking, excessive alcohol intake, and prolonged glucocorticoid (GC) use, have all been shown to confer risk independent of BMD measurement. These clinical features gave rise to risk assessment tools, such as the FRAX, which incorporates clinical risk factors with or without femoral neck BMD to estimate 10-year probabilities of hip and MOFs.[8] The ability of FRAX to predict fracture risk has been validated in independent cohorts.[9–11]

In addition, skeletal parameters other than BMD, such as bone geometry, microarchitecture, microdamage, rate of bone turnover, and mineralization, contribute to bone strength and risk of fracture.[12–14] As an example, bone microarchitecture assessed by high-resolution peripheral quantitative CT (HRpQCT) was able to differentiate between women with and without fragility fractures.[15,16] This technology, however, along with several methodologies that evaluate bone strength independent of BMD, are not readily available and are currently used as research tools.

Recently, the TBS was developed, a novel method that assesses skeletal texture from lumbar spine DXA images.[17,18] Longitudinal studies involving multiple cohorts and large numbers of subjects have shown that TBS improves fracture risk prediction beyond that provided by the combination of BMD by DXA and clinical risk factors. TBS is measured by dedicated software (TBS iNsight, Med-Imaps, Pessac, France), which has been cleared for clinical use in the United States to “assist the health care professional in assessment of fracture risk.” More recently, a task force of the International Society for Clinical Densitometry (ISCD) developed official positions on how to use TBS in clinical practice.[19] This article reviews technical and clinical aspects of TBS and its potential utility as a clinical tool to predict fracture risk.

TRABECULAR BONE SCORE: TECHNICAL ASPECTS

TBS is a textural index based on evaluating pixel gray-level variations in the lumbar spine (LS) DXA image, providing an indirect index of bone architecture. In general, well-structured bone generates a 2-D DXA image that is more homogeneous, with many gray-level variations of small amplitude. In contrast, deteriorated bone produces a 2-D image with a low number of pixel value variations of high amplitude.[18] TBS is derived from an experimental variogram of those projected images, calculated as the sum of the squared gray-level differences between pixels at a specific distance. The initial slope of the variogram represents the TBS (unitless), with a steeper variogram slope representing a well-structured bone, whereas a lower slope indicates less well-structured architecture. There is no consensus regarding what constitutes ‘‘normal’’ or ‘‘abnormal” TBS, but the manufacturer has proposed the following TBS cutoff points: TBS greater than or equal to 1.350 is considered normal; TBS values between 1.200 and 1.350 are consistent with partially degraded bone; and TBS less than or equal to 1.200 is taken to indicate degraded bone.[20]

TBS is typically measured at the LS (from L1 to L4) using the same regions of interest as for conventional BMD measurement, and the result is given for each vertebra and for the overall region of interest. The short-term in vivo precision ranges between 1.1% and 2.1%.[21–26] TBS can be applied to DXA images obtained from current generation fan-beam densitometers (Prodigy and Lunar iDXA, GE Healthcare; Delphi, QDR 4500, and Discovery, Hologic),[27] either at the time of the image acquisition or retrospectively. Similar to BMD derived from DXA, TBS results may not be comparable across different DXA machines or scan modes. A recent in vivo study showed greater TBS values derived from higher-resolution DXA images, as acquired using a Lunar iDXA scan, than those derived from lower-resolution images obtained on a Prodigy