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Original Article

Ethnic Differences in Trabecular Bone Score

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Abstract

Trabecular bone score (TBS), a noninvasive textural analysis of the lumbar spine dual-energy X-ray absorptiometry (DXA) image, has been shown to predict fractures in Caucasian (CA) populations but has not been thoroughly studied in African–American (AA) populations. The aim of this study was to compare the TBS in AAs and CAs and to assess whether TBS can be used to refine fracture risk stratification in AA patients. Eight hundred twenty-five women (390 AAs, 435 CAs) referred for bone mineral density (BMD) as part of their clinical care had measurements of the TBS, the BMD of the lumbar spine, total hip, and femoral neck, and vertebral fracture assessment for detection of vertebral fractures. Unadjusted TBS was higher in CA than AA (1.275 vs 1.238, $p < 0.001$), but this was no longer true after adjusting for age and tissue thickness. Interestingly, differences in TBS were still highly significant in those under 60 yr of age even with adjustment for tissue thickness, but not in older subjects. There were 74 CAs and 56 AAs with vertebral fractures on vertebral fracture assessment (17% vs 14%, $p = 0.30$). In CA, the odds ratio (OR) for prevalent vertebral fracture per SD decrease in TBS was 2.33 ($p < 0.001$), whereas in AA, the OR was 1.43 ($p = 0.02$). In a multivariate logistic regression model that also included age, BMD *T*-score, and glucocorticoid use, the association between TBS and prevalent vertebral fractures was still highly significant in CAs (OR 1.54, $p = 0.008$) but not in AAs (OR 1.23, $p = 0.21$). Our results suggest that TBS may be less discriminatory in regard to fracture risk in AAs than in CAs and that TBS may need to be used differently in these 2 ethnic groups.

Key Words: African–Americans; ethnic differences; trabecular bone score; vertebral fracture.

Background

Osteoporosis is a worldwide problem affecting people of all ethnic backgrounds. While bone mineral density (BMD) helps predict who will suffer from fractures, many patients who experience fractures do not have osteoporosis on BMD testing *(1)*. Recently, trabecular bone score (TBS) has been developed to further characterize fracture risk. TBS is derived from high-quality dual-energy X-ray absorptiometry (DXA) images and assesses pixel gray-level variations at the lumbar spine in a DXA image *(2)*. TBS is thought to relate to bone microarchitecture and has been shown to correlate with cortical thickness, trabecular number, and trabecular separation as measured by high-resolution peripheral quantitative computed tomography *(2)*.

Multiple studies have also shown the ability of TBS to predict fractures independently of BMD and clinical risk factors *(3–6)*. However, these studies have not included African–Americans (AAs), a population that suffers disproportionate morbidity and mortality after fractures *(7)*. AAs have higher BMD than other ethnicities *(8)* and, even at the same level of BMD, suffer fewer fractures *(9)*, suggesting advantages in bone quality. Previous bone biopsy and computed tomography studies have suggested both superior cortical and trabecular bone in AA *(10–12)*. Evaluation of trabecular bone with TBS, which can be done noninvasively and without the radiation risk of computed tomography, would provide more information regarding ethnic differences in bone structure. Further, it would be

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important to determine whether TBS could be used to refine fracture risk in AA patients, leading to a more aggressive therapeutic approach among those at high risk of fracture in this population that is typically undertreated *(7)*.

In the only study available to date, healthy postmenopausal AA women had higher TBS values than values previously reported in the literature for Caucasians (CAs) *(13)*. However, no study has evaluated TBS in a densitometry population of AAs (i.e., not healthy volunteers) who are likely at higher fracture risk or assessed the association of TBS and fractures in AAs. Thus, the purpose of our study was to compare the TBS of AA and CA women referred for BMD testing and to determine whether TBS can be used for stratification of fracture risk in AAs.

Methods

Study Subjects

This is a secondary analysis of patients previously recruited when they presented for BMD testing as part of their clinical care. A convenience sample of 1318 women were recruited between 2001 and 2012 and were the subjects of a previously published study *(14)*. For the analyses presented here, we excluded women not of CA or AA ethnicity and women under age 40, leaving 891 women (429 AAs and 462 CAs). For the primary analyses, we included only 825 patients (390 AAs and 435 CAs) with body mass indices (BMIs) of 15–37, as this is the working BMI range for TBS *(6)*. Patients referred for BMD testing are generally residents of Chicago or Northwest Indiana and receive either primary or tertiary care at the University of Chicago Medicine. The present study was approved by the University of Chicago Institutional Review Board. All patients signed informed written consents.

Measurements

The patients completed a questionnaire that provided information on personal and family history of fractures and their circumstances, young adult height and weight, medical history, medication use, and personal habits such as smoking, alcohol consumption, calcium intake, and activity level. Height and weight were measured using standard clinical equipment.

All vertebral fracture assessments (VFAs) and lumbar spine and proximal femoral DXA scans were performed using Prodigy scanners (GE Healthcare, Madison, WI) and analyzed (enCORE Software 12.4, GE Healthcare) in accordance with manufacturer recommendations. Femoral neck and total hip *T*-scores and *Z*-scores were calculated using the Third National Health and Nutrition Examination Survey (NHANES III) white female reference values, while the lumbar spine scores were derived using the manufacturer's database. The 2 instruments used in the present study were cross-calibrated using anthropomorphic phantoms.

All VFA images were evaluated by an International Society of Clinical Densitometry (ISCD) trained clinician (TV) using the Genant semiquantitative approach, as recommended by the ISCD *(15)*. Vertebrae were visualized from T6 to L4, and fractures (if found) were assigned grade 1 for a 20%–25% reduction in vertebral height, grade 2 for a 26%–40% reduction, or grade 3 for a >40% reduction with good inter-reader reliability as previously reported *(16)*. Only fractures with grade 2 or higher were considered for analyses, as grade 1 fractures are more likely to be due to nonfracture deformities and are not as predictive of future fractures as grade 2 or 3 fractures.

TBS measurements were performed in the Bone Disease Unit at the University of Lausanne, Lausanne, Switzerland (TBS iNsight® Software version 2.1; Med-Imaps, Pessac, France) using anonymized spine DXA files from the University of Chicago to ensure blinding of the Swiss investigators to all clinical parameters and outcomes. The software uses the anteroposterior spine raw image(s) from the densitometer, including the BMD region of interest (ROI) and edge detection, so that the TBS calculation is performed over exactly the same ROI as the BMD measurement. In the current analysis, we used a research version of the commercialized TBS iNsight software, which allows for large batched analyses from a work station. Tissue thickness is a variable generated by the TBS program, which captures the thickness of soft tissue in the window where TBS is measured. TBS precision, measured as the coefficient of variation, is 1.12%–2.1% *(2)*.

Definitions of Risk Factors Used in Analysis

Ethnicity was self-reported by the patient as Caucasian (CA), black (AA), Asian, or Hispanic. Nonvertebral (peripheral) fracture was defined as any fracture occurring after the age of 45, in the course of usual physical activity, excluding fractures of the face, fingers, and toes, or those resulting from a motor vehicle accident. Glucocorticoid use (systemic but not inhaled) was defined as at least 5 mg/d of prednisone or equivalent for at least 3 mo (cumulative exposure equivalent to at least 0.450 g of prednisone), as was recommended by the American College of Rheumatology at the time the study subjects were recruited *(17)*. For BMD measurement, the lowest of the lumbar spine, femoral neck, or total hip *T*-scores (labeled low *T*) was used for analysis as recommended by the ISCD *(15)*. Obesity was defined as a BMI of 30 kg/m^2 or greater.

Statistical Analysis

All statistical analyses were performed using STATA 13 (StataCorp, College Station, TX, USA). To assess ethnic differences in the clinical characteristics and risk factors, we used *t*-test for continuous variables and chi-square tests for categorical variables. TBS standardized (TBSstd) was defined as the number of standard deviations (SD) away from the mean of our study sample. Linear regression analysis was used to examine the relationship between TBS and biological variables that are known to influence bone strength. The association between vertebral or nonvertebral fractures, standardized TBS, and other risk factors was modeled using logistic regression.