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Section I: Fracture Risk Assessment

Utility of Heel Dual-Energy X-ray Absorptiometry in Diagnosing Osteoporosis

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Abstract

Although peripheral dual-energy X-ray absorptiometry measurements have been found to predict fractures in population studies of white subjects, little is known about their utility in other races and in patients with greater risk of fracture. In a cross-sectional study of 874 women referred for bone mineral density (BMD) testing, we examined the utility of heel BMD in African-American (AA) compared with Caucasian (CA) women and in women using glucocorticoids. The ability of heel T-score to predict central osteoporosis was similar in AA and CA women (odds ratio [OR] per 1 unit decrease in T-score of 2.79 [95% confidence interval {CI} 2.16–3.60] and 3.15 [95% CI 2.53–3.92], respectively). The association between heel T-score and prevalent vertebral fractures was also similar in the 2 groups (OR 1.46 [95% CI 1.15–1.85] in AA and 1.42 [95% CI 1.16–1.74] in CA). In women using glucocorticoids heel T-score was better than central T-score in predicting vertebral fractures (OR 1.38 [95% CI 1.03–1.85] and 1.22 [95% CI 0.86–1.73], respectively). We conclude that in a multiracial referral population heel BMD predicts central osteoporosis and prevalent vertebral fractures equally well in AA as in CA women and may be better than central BMD in assessing fragility in glucocorticoid users.

Key Words: Heel bone mineral density; osteoporosis; peripheral bone densitometry; racial differences.

Introduction

Bone mineral density (BMD) measurements at the lumbar spine and proximal femur are considered the gold standard for assessing fracture risk, diagnosing osteoporosis according to the criteria set by the World Health Organization, and selecting patients for therapy. Although measuring BMD by the use of dual-energy X-ray absorptiometry (DXA) has been associated with lower rates of hip fracture *(1)*, as few as 32% of patients with indications for osteoporosis screening undergo BMD testing *(2)*. Even in high-risk populations, average BMD testing rates were 8% in patients with fractures and 9% in patients using oral glucocorticoids *(3–5)*. Access to DXA scanners has been associated with increased likelihood of BMD ordering and testing *(6–8)*. However, the availability of central densitometers remains limited in many parts of the world, and in societies that have access reimbursement for central DXA testing has decreased, resulting in fewer physician offices providing this service *(9)*. Thus, peripheral DXA scanners, which are cheaper, smaller, and more portable allowing for implementation in primary care settings, may serve as an attractive alternative to central DXA *(10)*.

Several studies have shown that peripheral BMD measurements are useful for assessing fracture risk *(11–15)*, selecting patients who should have BMD measured at central sites, and deciding which patients should be offered pharmacologic therapy for osteoporosis *(16–19)*. Most of these studies were population-based and included predominantly white subjects. It is not clear whether the same conclusions would apply to African-American patients or to patients who have greater risk of fracture, such as those referred for bone densitometry or patients taking glucocorticoids. To address these questions, we studied a convenience sample of a multiracial population of patients referred for BMD measurement. We

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examined the association of anthropologic variables with heel and central BMD, the utility of heel BMD in diagnosing central osteoporosis in African-American (AA) compared with Caucasian (CA) women, and the utility of heel BMD in evaluating bone fragility in patients with history of glucocorticoid use.

Methodology

Subjects

A total of 1075 ambulatory subjects were recruited over 7 years. This was a convenience sample; subjects were recruited when they presented for BMD measurement ordered for routine medical care. The densitometry facility performs all BMD testing at the University of Chicago; patients are referred by University of Chicago physicians and include primary and tertiary care patients. There were no specific inclusion criteria; patients were recruited if study personnel were present, the densitometry technologist had time to perform additional images, and the patients agreed to participate. The study was approved by the Institutional Review Board at the University of Chicago, and all participants provided informed consent.

Measurements

Each subject completed a questionnaire that included information on personal and family history of fractures and their circumstances, young adult height, recent changes in weight, medical history, medication use, and personal habits such as tobacco use, alcohol consumption, calcium intake, and activity level. Height and weight were measured using standard clinic equipment. The 10-yr probability of having a major osteoporotic fracture was calculated using the web-based World Health Organization fracture risk assessment tool (FRAX) calculator (www.shef.ac.uk/FRAX).

BMD measurements of the lumbar spine and proximal femur and Vertebral Fracture Assessment (VFA) were obtained by 2 technologists certified by the International Society for Clinical Densitometry (ISCD), who used the Prodigy densitometer (GE Medical Systems, Madison, WI). The precisions of BMD measurements were 1% for the lumbar spine and total hip and 1.5% for the femoral neck. Data from the third National Health and Nutrition Examination and Survey were used to derive T-scores (sex-adjusted white norms) and Z-scores (age-, sex-, race-, and weight-adjusted norms). As recommended by ISCD *(20)*, BMD of L1-L4 with elimination of artifact-laden vertebrae was used to derive lumbar spine T-score, and the lower BMD value was used for femoral neck and total hip T-scores. Heel BMD was obtained in duplicate with the Peripheral Instantaneous X-Ray Imager (PIXI; GE Medical Systems) with the mean of 2 measurements used for analyses. The precision of the heel BMD measurement was 1.8%.

All VFA images were evaluated by one ISCD-trained clinician (T.V.) using the Genant semiquantitative approach *(21)*, as recommended by the ISCD *(22,23)*. Fractures were assigned a grade: grade 1 fracture represents a 20%−25% reduction in vertebral height, grade 2 a 26%−40% reduction, and grade 3 a >40% reduction. Only fractures with grade 2 or greater were considered for analyses as grade 1 fractures may be due to nonfracture deformities *(24)* and are not predictive of future fractures *(25)*.

Definition of Variables

Race was provided by the patient. Categories included AA, CA, Asian, and Hispanic. Vertebral fracture was a binary variable (yes or no) and referred to having at least a grade 2 fracture on VFA. Peripheral fracture was a binary variable and referred to a nonvertebral fragility fracture that occurred after the age of 50. Fragility fracture includes either vertebral fracture and/or peripheral fracture. Glucocorticoid use was a binary variable and defined as at least 5 mg/day of systemic prednisone use or its equivalent for at least 3 months *(26)*. Osteoporosis treatment was defined as the patient receiving any of the following medications: estrogen (excluding vaginal preparations), raloxifene, tamoxifen, bisphosphonates, calcitonin, or teriparatide.

Statistical Analysis

Differences between subgroups of patients were examined using t-tests for continuous and χ^2 tests for categorical variables. The correlations between heel BMD and anthropometric variables were examined using Pearson correlation. The association between heel and central T-score was modeled using linear regression with heel T-score as the outcome, whereas the association of fractures and heel or central T-score was modeled using logistic regression with presence of fractures as a binary outcome. All analyses were performed using STATA 11 statistical software package.

Results

Clinical Characteristics

Among the 1075 subjects who consented to the study, results from 976 were available for analyses. Subjects were excluded if heel scans were not obtained, the positioning of the heel was poor, or the heel was too large to fit in the PIXI positioner. The clinical characteristics of the subjects included in the analyses are shown in Table 1. All mean Z-scores were significantly lower than zero ($p < 0.0001$), indicating that this study population had lower BMD than the general population. Compared with female subjects, male subjects had lower BMD Z-scores, a greater prevalence of vertebral fractures, and a greater prevalence of glucocorticoid use. In both sexes, heel T-scores were significantly greater than proximal femur sites ($p < 0.0001$) but not greater than the spine, where degenerative changes likely artifactually increase BMD.

Relationship of BMD to Anthropometric Characteristics

The correlations between anthropometric variables and BMD of the heel and central sites are shown in Table 2. Heel BMD correlated significantly with BMD of the central sites, particularly of the total hip. Correlation between hip