Acta Orthopaedica et Traumatologica Turcica xxx (2016) 1–6

Contents lists available at ScienceDirect

Acta Orthopaedica et Traumatologica Turcica

journal homepage: https://www.elsevier.com/locate/aott

Discriminative ability of calcaneal quantitative ultrasound compared with dual-energy X-ray absorptiometry in men with hip or distal forearm fractures

Fatih Cesme, Sina Esmaeilzadeh*, Aydan Oral

Istanbul University, Istanbul Faculty of Medicine, Istanbul, Turkey

ARTICLE INFO

Article history:
Received 1 September 2015
Accepted 25 December 2015
Available online xxx

Keywords:
Calcaneal quantitative ultrasound
Distal forearm fractures
Dual-energy X-ray absorptiometry
Hip fractures
Osteoporosis

ABSTRACT

Objectives: The aim of this case–control study was to compare the discriminatory ability of bone mineral density (BMD) measurements and calcaneal quantitative ultrasound (QUS) parameters for fractures and to determine fracture thresholds for each variable in men with hip or distal forearm fractures.
Patients and methods: A total of 20 men with hip and 18 men with distal forearm fractures and 38 age-matched controls were included in this study. Dual-energy X-ray absorptiometry (DXA) BMD (spine and hip) and calcaneal QUS measurements were made. Area under the curves (AUCs) were calculated to assess fracture discriminatory power of DXA and QUS variables.
Results: Quantitative Ultrasound Index (QUI) T-score and Speed of Sound (SOS) were found to be the best parameters for the identification of hip and distal forearm fractures, respectively, with AUCs greater than those of DXA BMD and other QUS parameters. While a QUI T-score of ≤ -1.18 could identify and rule out hip fracture cases with approximately 80% sensitivity and specificity, a SOS value of ≤ 1529.75 reached to almost 90% for ruling in and out distal forearm fractures.
Conclusion: The discriminatory performance of calcaneal QUS variables between fractured and non-fractured men was as good as those of the DXA BMD and even better. Since men appear to sustain fractures at closer QUS variable levels than those of the DXA BMD regardless of the fracture type, it may be speculated that calcaneal QUS may be more helpful in predicting the risk of fractures when BMD alone does not demonstrate impaired bones.
Level of Evidence: Level III, Study of Diagnostic Test

Introduction

The most common osteoporotic fractures include distal forearm fractures (DFFs), hip fractures (HFs), and vertebral fractures with an estimated number of 1.7, 1.6, and 1.4 million, respectively, in 2000.[1] The remaining life-course probability of a HF and a DFF at age 50 was estimated as 10.7% and 22.9% in men, respectively.[2]

The association between HFs and mortality is well established in both genders, being higher in males.[3] Increasing evidence also suggests an increased risk for premature mortality in those with DFFs.[4] Osteoporotic fractures may also cause significant disability[5] as well as tremendous societal and economic impact.[1] Therefore, it is crucial to predict the risk of osteoporotic fractures and/or to identify bone characteristics of fracturers to apply evidence-based pharmacological and non-pharmacological treatment options for prevention.[5,6]

While dual energy X-ray absorptiometry (DXA) bone mineral density (BMD) measurement is the gold standard for predicting HFs,[7] two meta-analyses of prospective studies showed that calcaneal quantitative ultrasound (cQUS) variables were strong predictors of non-spinal fracture risk, in both men and women usually in a way comparable to DXA-BMD measurements.[8,9] cQUS studies are not as many as in men than they are in women.[9] A number of case–control studies provided evidence on the fracture discriminatory ability of cQUS in men[10–14] however, very few of them assessed cut-off values for QUS variables for fractures providing us with any osteoporotic fracture thresholds while not defining separate cutoff points for HFs or DFFs.[15,16]

* Corresponding author. Istanbul University, Istanbul Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Millet Cad, Capa, Fatih, 34093, Istanbul, Turkey.
E-mail address: sinabox@gmail.com (S. Esmaeilzadeh).
Peer review under responsibility of Turkish Association of Orthopaedics and Traumatology.

http://dx.doi.org/10.1016/j.aott.2016.08.006

The aim of this case–control study was two-fold: to compare the fracture discriminatory ability of cQUS parameters and DXA-BMD measurements and to determine fracture thresholds for DXA-BMD and cQUS variables separately for HFs or DFFs in men.

Patients and methods

Participants

The study participants consisted of 38 men with low-energy fractures in the period of 6 months after fracture, 20 having HFs and 18 having DFFs and 38 age-matched men (±2 years than each fracturer) without any fracture, disease, or medications known to affect bone metabolism as the control group. All of the subjects filled out a questionnaire including information such as age, height and weight, handedness, smoking status, physical activity level (the time spent for walking before the fracture categorized as <1, 1–2, and >2 h a week), a family or own history of osteoporotic fracture, and information for fracturers such as type and side of fracture, and time since fracture. Participants had cQUS and DXA-BMD measurements. The study protocol was approved by the local Ethics Committee and written informed consent was obtained from all of the participants.

DXA measurements

DXA-BMD measurements were made using a Hologic QDR 1000 DXA device (Hologic, Waltham, MA, USA) at posteroanterior spine and hip (at the non-fractured side in the fracturers and at the non-dominant side in the controls). Hip fractured men were ambulatory, being able to come to our bone densitometry unit for testing. The BMD of the vertebrae from L1 to L4 at the lumbar spine (LS) and femoral neck (FN), and total femur BMD at the hip were included in the data analysis. The presence of osteoporosis at any region of interest (ROI) was defined as a T-score ≤ -2.5. A T-score between -1 and -2.5 was classified as low bone mass/osteopenia and a T-score ≥ -1 was classified as normal.[17] However, Z-scores of ≤ -2.0 were used for defining BMD "below the expected range for age," (osteoporosis), while Z-scores > -2.0 were considered "within the expected range for age" (normal) in those <50 years.[18] An individual was considered as osteoporotic in the presence of a T-score ≤ -2.5 or a Z-score ≤ -2.0 (<50 years) in any of the ROI.

QUS measurements

Acoustic parameters of bone were measured using a portable, gel-coupled cQUS device (Sahara® Clinical Bone Sonometer, Hologic, Waltham, MA, USA). This device measures broadband ultrasound attenuation (BUA) (dB/MHz) and the speed of sound (SOS) (m/s) and calculates Quantitative Ultrasound Index (QUI) as well as a QUI T-score and estimated heel BMD (eBMD) (g/cm^2). Daily quality control was performed using a phantom provided by the manufacturer. Given the findings that considerable differences may exist between sides as found in women[19] both heel measurements were made and repeated with repositioning of the feet. The mean of the two measurements were calculated for both feet and the lowest mean value of QUS variables obtained for the two sides was included in statistical analyses, except for the hip fractured men in whom the mean of QUS measurements of the non-fractured side was used.

Precision of cQUS parameters

The short-term precision of the QUS variables was examined as recommended by Glüer et al using the double measurements obtained in all subjects with repositioning of the feet as the root-mean-square coefficient of variation (RMS-%CV) according to the following formula: RMS-%CV $= \sqrt{\sum CVi^2/n} \times 100$ (CV: coefficient of variation).[20]

Statistical analysis

For statistical analyses, SPSS software, version 17.0 (SPSS Inc., Chicago, IL, USA) was employed. We used Student's t-test and Chi square tests to compare continuous and dichotomous variables, respectively, in fracturers and non-fracturers. Receiver operating characteristic (ROC) analysis was used to determine fracture discriminatory ability of QUS and BMD variables. Areas under the ROC curves (AUCs) were calculated for each variable. The sensitivity and specificity of various cut-off points for each variable in ROC curves showing the best balance were used to determine fracture thresholds for variables. Significance was set at $p < 0.05$.

Results

One participant with a HF and a HF control did not have a spine BMD measurement due to metal implants in one and positioning difficulties in the other. A man with a HF and the other with a DFF did not have a hip DXA measurement due to positioning problems. Characteristics of study participants are shown in Table 1. BMD and QUS variables are displayed in Table 2. AUCs are given in Table 3. Various cut-off values for BMD and QUS variables and their sensitivity and specificity are shown in Table 4. The precision of QUS variables are shown in Table 5.

Discussion

As expected, the results of this study revealed significantly lower values for both DXA-BMD and cQUS variables in those with fractures when compared with those without (Table 2) in line with other studies comparing DXA and QUS variables for the identification of hip,[11,21,22] lower extremity,[14] or all osteoporosis-related fractures.[23,24] Studies using only QUS in men also demonstrated significantly lower QUS variables in fracturers than non-fracturers.[10,12,13,15,16]

The ability of DXA-BMD measurements in separating men with HF or DFFs from those without could be considered as "fair" or "good" with AUCs ranging from 0.772 (for FN T-score) to 0.838 (for L1–L4 T-score) for HFs and 0.775 (for L1–L4 BMD) to 0.891 (for FN T-score) for DFFs (Table 3). It was interesting to note that discriminative power of L1–L4 BMD was higher than that of the FNBMD for HFs as reflected by AUCs (0.836 vs. 0.778) and vice versa for DFFs (0.775 vs. 0.876), despite the findings of a strong association with risk of HF, and FNBMD in men and weaker association with LSBMD.[25] However, another study did show the equally good predictive ability of LS and FNBMD for various types of fractures in women.[26] Supporting this finding, two studies in men with any osteoporotic fractures demonstrated a better discrimination power of LSBMD than that of FNBMD, AUC values for LS vs. FNBMD being 0.800 vs. 0.730 and 0.668 vs. 0.643, possibly resulting from the inclusion of relatively fewer number of men with non-spinal fractures. Whether these findings apply to HFs alone in men remains to be further investigated in large-scale prospective studies. As for DFFs, in parallel with our findings, FNBMD was found a significant risk factor.[23,27,28]

cQUS variables discriminated men with HFs or DFFs in a way comparable to DXA-BMD measurements with similar or slightly greater AUCs varying from 0.819 (for BUA) to 0.841 (for QUI T-score), implying "good" discriminatory ability. For men with DFFs, all QUS variables, with the exception of BUA, could be considered as

Please cite this article in press as: Cesme F, et al., Discriminative ability of calcaneal quantitative ultrasound compared with dual-energy X-ray absorptiometry in men with hip or distal forearm fractures, Acta Orthop Traumatol Turc (2016), http://dx.doi.org/10.1016/j.aott.2016.08.006