SCIENTIFIC ARTICLE

Simple Assessment of Global Bone Density and Osteoporosis Screening Using Standard Radiographs of the Hand

Joseph J. Schreiber, MD,* Robin N. Kamal, MD,* Jeffrey Yao, MD*

Purpose Osteoporosis and fragility fractures have consequences both at the individual level and to the overall health care system. Although dual-energy x-ray absorptiometry (DXA) is the reference standard for assessing bone mineral density (BMD), other, simpler tools may be able to screen bone quality provisionally and signal the need for intervention. We hypothesized that the second metacarpal cortical percentage (2MCP) calculated from standard radiographs of the hand or wrist would correlate with hip BMD derived from DXA and could provide a simple screening tool for osteoporosis.

Methods Two hundred patients who had hand or wrist radiographs and hip DXA scans within 1 year of each other were included in this series. Mid-diaphyseal 2MCP was calculated as the ratio of the cortical diameter to the total diameter. We assessed the correlation between 2MCP and total hip BMD. Subjects were stratified into normal, osteopenic, and osteoporotic cohorts based on hip *t* scores, and thresholds were identified to optimize screening sensitivity and specificity.

Results Second metacarpal cortical percentage correlated significantly with BMD and *t* scores from the hip. A 2MCP threshold of less than 60% optimized sensitivity (88%) and specificity (60%) for discerning osteopenic subjects from normal subjects, whereas a threshold of less than 50% optimized sensitivity (100%) and specificity (91%) for differentiating osteoporotic from normal subjects.

Conclusions By demonstrating that global BMD may be assessed from 2MCP, these data suggest that radiographs of the hand and wrist may have a role in accurately screening for osteopenia and osteoporosis. This simple investigation, which is already used ubiquitously for patients with hand or wrist problems, may identify patients at risk for fragility fractures and allow for appropriate referral or treatment. *(J Hand Surg Am. 2017;■(■):■−■. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Diagnostic II.

Key words Hand radiographs, osteoporosis.

*From the *Stanford University Medical Center, Redwood City, CA.*

Received for publication June 27, 2016; accepted in revised form January 9, 2017.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: Joseph J. Schreiber, MD, Stanford University Medical Center, 450 Broadway Street, Pavilion A, Redwood City, CA 94063; e-mail: josephs2@stanford.edu.

0363-5023/17/■ ■-0001$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2017.01.012

OSTEOPOROSIS-RELATED FRAGILITY fractures, such as those of distal radius, hip, and vertebral compression, are frequently encountered by clinicians. In the United States alone, there are over 2 million fragility fractures annually, which places a major financial burden on the health care system, estimated to exceed $20 billion each year.[1] The global population is aging exponentially, with 500 million individuals currently aged over 65 years. This figure

will increase to 1.3 billion by 2040.[2] This is expected to result in a two- to fourfold increase in osteoporotic fragility fractures over this timeline.[3] Multiple studies have shown that the rates of intervention and appropriate management of these patients are disappointingly low[4,5] although it is known that screening for osteoporosis and initiating treatment have been shown to decrease future risk of fragility fractures.[6,7]

Although it is essential to manage postfracture patients adequately, it is also critically important to identify individuals at increased risk before the occurrence of these fractures. There must be a shift of osteoporosis management from a reactive to a predictive field. Dual-energy x-ray absorptiometry (DXA) is currently the reference standard for quantifying bone mineral density (BMD) and is used to assess fracture risk and dictate treatment.[8] The World Health Organization (WHO) definition of osteoporosis is widely accepted and based on DXA *t* scores, defined as the number of SDs an individual's BMD differs from control values based on a young and healthy population.[9] According to the United States Preventive Services Task Force, osteoporosis screening is currently recommended for women aged 65 years or older and in those with equivalent risk.[10] These narrow recommendations exclude males and individuals with high but not yet identified risk.

Osteoporosis is thought to be a systemic disease with diffuse effects on the appendicular skeleton.[11,12] As such, there may be information on plain radiographs, regardless of anatomic region, that provides insight into an individual's bone quality. We hypothesized that commonly obtained simple radiographs of the hand and wrist, with particular focus on the cortical percentage of the second metacarpal, would correlate with hip DXA results and could provide clinicians with a simple screening tool for osteoporosis.

MATERIALS AND METHODS

Study cohort

We obtained institutional review board approval for this retrospective case series. Our institution's picture archiving and communications system (PACS) (GE Healthcare Centricity, Chicago, IL) was queried between 2014 and 2016 to identify individuals who had either hand or wrist digital radiographs along with a DXA scan within 12 months of each other. A complete posteroanterior (PA) view of the second metacarpal on either hand or wrist radiographs was necessary for inclusion in the study. Exclusion criteria were subjects with incomplete hip DXA results and those with radiographs that had casting material or hardware overlying or in the hand. The preliminary search revealed 211 patients. Five patients were excluded owing to incomplete hip DXA results, 3 to lack of a PA view of the hand in the radiographic series, 2 to casting material overlying the hand, and 1 to an external fixator that was present in the second metacarpal. The final cohort consisted of 200 patients.

Second metacarpal cortical percentage calculation

We used a true PA view of the hand from either digital hand or wrist radiographs. When multiple hand radiographs were present for a subject, the earliest was chosen to minimize potential disuse osteopenia changes related to intervention and/or immobilization. The mid-diaphysis of the second metacarpal was localized and the PACS magnification function was employed to optimize visualization. The second metacarpal was chosen because there is a historical precedence for using this site for bone quality assessments.[13] In addition, it is visible on hand and wrist radiographs, it is relatively cylindrical and therefore resistant to rotational effects, and given its role in pinching and grasping, it may be a surrogate marker of activity and strength. The transverse diameter of the second metacarpal was measured at the isthmus, that is, its narrowest, mid-diaphyseal portion (A). A second, parallel, measurement was made of the cancellous or intramedullary component at the same location (B). We used the formula $[(A - B) / A] \times 100$ to generate a second metacarpal cortical percentage (Fig. 1). Because this is a ratio of cortical diameter relative to total diameter, absolute values are unimportant and no calibration is required. All measurements were made by 2 independent observers who were blinded to DXA results.

Statistical analysis

Ranges for continuous variables are reported, as are means and SDs. A 2-tailed Pearson r analysis was used to assess the correlation between second metacarpal cortical percentage (2MCP) and both DXA-defined hip BMD (g/cm^2) and *t* scores. We used hip *t* scores to stratify patients into 3 subcohorts based on WHO definitions of normal (hip *t* score −1.0 or more), osteopenic (−1.0 less than hip *t* score greater than −2.5), and osteoporotic (hip *t* score −2.5 or less).[9] *T* scores are commonly used to determine treatment stratification.[14] However, because some data are lost when converting continuous BMD data into categorical data, we also reported the association between 2MCP and BMD. A receiver-operating characteristic (ROC) curve was used to identify threshold values for 2MCP that would optimize