EDITOR'S CHOICE

Using Hounsfield Units to Assess Osteoporotic Status on Wrist Computed Tomography Scans: Comparison With Dual Energy X-Ray Absorptiometry

Christine C. Johnson, MD,* Elizabeth B. Gausden, MD,* Andrew J. Weiland, MD,* Joseph M. Lane, MD,* Joseph J. Schreiber, MD*

Purpose Rates of evaluation and treatment for osteoporosis following distal radius fragility fractures remain low. As a subset of patients with these fractures undergo diagnostic computed tomography (CT) scan of the wrist, utilizing bone mineral density (BMD) measurements available with this imaging can be used to detect osteopenia or osteoporosis. This information may consequently prompt intervention to prevent a subsequent fracture. The purpose of this study was to determine if Hounsfield unit (HU) measurements at the wrist correlate with BMD measurements of the hip, femoral neck, and lumbar spine and to assess the ability of these HU measurements to detect osteoporosis of the hip.

Methods Forty-five female patients with distal radius fractures who underwent CT scan and dual energy x-ray absorptiometry scan as part of the management of their wrist fracture were identified. Bone mineral density measurements were made using the regional cancellous bone HU value at the capitate and compared with values obtained by a dual energy x-ray absorptiometry scan.

Results Hounsfield unit values at the capitate were significantly correlated with BMD and *t* scores at the femoral neck, hip, and lumbar spine. An HU threshold of 307 in the capitate optimized sensitivity (86%) and specificity (94%) for detecting osteoporotic patients.

Conclusions By demonstrating that capitate HU measurements from clinical CT scans are correlated with BMD and *t* scores at the hip, femoral neck, and lumbar spine, our data suggest that clinical CT scans should have a role in detecting osteopenia and osteoporosis. *(J Hand Surg Am. 2016;41(7):767–774.*

Type of study/level of evidence Diagnostic III.

Key words Bone mineral density, distal radius fracture, dual x-ray absorptiometry, Hounsfield unit, osteoporosis.

*From the *Hospital for Special Surgery, New York, NY.*

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Corresponding author: Christine C. Johnson, MD, Hospital for Special Surgery, 525 East 70th St., New York, NY 10021; e-mail: johnsonc@hss.edu.

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THE INCIDENCE OF OSTEOPOROTIC fragility fractures is expected to increase 2- to 4-fold in the next 30 years, which will potentially place a major burden on the health care system.[1–3] Numerous efforts have been made at the national level to focus on improving the identification and evaluation of high-risk individuals.[2] A history of a fragility fracture is one of the strongest risk factors for developing a subsequent fracture, and a fragility fracture of the wrist is associated

with a 5-fold increase in sustaining a vertebral fracture and a 3-fold increase in sustaining a hip fracture in the future.[4,5] Because fragility fractures of the wrist typically occur about 15 years prior to a hip fracture, it has been recommended that interventions be targeted to this group.[6–9]

Medical management of osteoporosis following distal radius fractures can effectively lower a patient's risk of developing a hip or vertebral fracture[10]; bisphosphonate therapy alone has been shown to reduce fracture risk by up to 70%.[11] However, only a fraction of patients who sustain a fragility fracture are diagnosed with osteoporosis, and less than 10% of those diagnosed are started on treatment.[12,13] The reason for the gap between evidence-based treatment guidelines and treatment rates remains unclear, although several barriers have been suggested and explored. For one, there is often confusion regarding which physician is responsible for treating osteoporosis following a fragility fracture.[12,14] Other barriers include the cost of medication and patient transportation issues.[15–17] Orthopedic surgeons who treat distal radius fractures are in a unique position to identify patients who could benefit from osteoporosis evaluation, and level I evidence indicates improved rates of evaluation and treatment when this is initiated by orthopedic surgeons.[12,18] Patients with distal radius fractures are a high-risk group that should be targeted for screening, but as few as 2.8% of women undergo a bone mineral density (BMD) test after sustaining a wrist fragility fracture.[6–9]

Measurement of BMD using dual energy x-ray absorptiometry (DEXA) remains the gold standard for the diagnosis of osteoporosis and is ideal for screening secondary to its minimal radiation exposure and low cost. The widely accepted World Health Organization (WHO) definition of osteoporosis is based on the DEXA *t* score, which is defined as the number of SDs by which the recorded bone density differs from a control value derived from the mean and SD of values in a young healthy population.[19] For patients who have not undergone DEXA screening, alternative methods for identifying those at risk may be readily available and should be considered.

There is mounting evidence in the literature that information about bone quality can also be ascertained via Hounsfield unit (HU) measurements obtained from diagnostic computed tomography (CT) scans.[20,21] An HU value is a standardized linear attenuation coefficient of tissue, based on a defined scale of 0 for water and −1,000 for air, that represents the density of tissue. Values are calculated from the following formula: $HU = ((\mu - \mu_w)/\mu_w) \times 1000$, with μ defined as the linear x-ray attenuation coefficient of the selected tissue and μ_w the attenuation coefficient of water.[22,23] Hounsfield unit measurements can be calculated from a region of interest (ROI) using most modern radiology imaging software without added costs or radiation.

Measuring HU from CT has generated accurate estimates of BMD in the spine.[20,22] In a recent study, patients with distal radius fractures had significantly lower HU measurements in wrist CTs than patients without distal radius fractures,[24] but to our knowledge, the relationship between HU measurements and DEXA scores has not yet been investigated in the wrist. Given that the vast majority of patients fail to obtain a DEXA scan after sustaining a fragility fracture of the wrist, establishing HU thresholds for the diagnosis of osteoporosis and osteopenia from wrist CT scans may have the potential to improve rates of osteoporosis treatment in this population.

The purpose of this study was to assess the ability of HU measurements of the capitate on clinical CT scans to detect osteoporosis or osteopenia of the hip. We chose hip BMD as our primary outcome because hip fracture risk prediction is determined by hip BMD,[20,25] and hip BMD is more predictive of future fractures than spine or peripheral BMD measures.[26–30] Bone mineral density and *t* scores at the femoral neck and lumbar spine were included as secondary outcomes. We hypothesized that HU measurements of the capitate on clinical CT scans would correlate with BMD measurements and *t* scores at the hip, femoral neck, and lumbar spine.

PATIENTS AND METHODS

Study cohort

Institutional review board approval was obtained for this retrospective case series. Inclusion criteria were presence of a distal radius fracture, female gender, and a DEXA scan within 12 months of the distal radius fracture. Nine hundred seven distal radius fractures were identified on CT scans archived in a picture archiving and communication system between 2005 and 2015 at our institution. Fifty-three of these 907 fractures underwent a DEXA scan within 12 months of the distal radius fracture. Of the 53 distal radius fractures that met initial inclusion criteria, 3 were excluded on the basis of incomplete DEXA results. The study was limited to females because average HU measurements vary based on gender.[23,24] Thus, the 5 male patients were also excluded from the study. Our final cohort consisted of 45 female patients who had a diagnostic CT scan documenting a distal radius fracture between 2005 and 2015 and a DEXA within 12 months of that diagnosis.