Utilization and Reporting of Bone Densitometry:

What Can the Musculoskeletal Radiologist Do to Help, Rather Than to Hurt?

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Osteoporosis is a highly prevalent disease that predisposes patients to fragility fractures. These fractures carry serious risks, including increased mortality and the potential loss of functional independence. Effective treatments for osteoporosis are available, but these should be initiated before a fragility fracture actually occurs; to do so, osteoporosis must be diagnosed while it is still asymptomatic. The gold standard screening test used to detect low bone mass is dual-energy x-ray absorptiometry (DXA). Despite its clinical importance, the DXA report is sometimes neglected by radiologists—as though it were somehow less significant in diagnosis than our other modalities. If musculoskeletal radiologists are to help, rather than to hurt, we must raise the profile of this critical test with evidence-based utilization and coherent reporting: detailed recommendations for doing so are available from professional organizations such as the International Society for Clinical Densitometry and the National Osteoporosis Foundation. This brief survey will seek to remind the radiologist that a good densitometry report requires more than just copying numbers from a scanner.

Key Words: DXA; densitometry; osteoporosis.

Osteoporosis is the structural weakening of bones—whether from age, disease, or medication. Although the full structural physiology of bones is complex, a major source of their strength is derived from their calcified matrix (1). Thus, the bone mineral density (BMD), a measure that serves as a surrogate for the quantity of calcium in a bone, has a strong inverse correlation with the risk of osteoporotic fractures (2). As we will see, this association forms the basis of screening for osteoporosis.

Why does osteoporosis matter? It is a prevalent and highly morbid disease. Nearly half of all postmenopausal women will have an osteoporotic fracture in their lifetimes, with absolute rates increasing with the aging population (1,3,4). For example, in a large prospective study of 14,000 Europeans, the incidence of vertebral fractures in women per 1000 person-years increased exponentially with age: 3.6 (ages 50–54 years), 5.5 (ages 55–59 years), 9.5 (ages 60–64 years), 12.3 (ages 65–69 years), 17.9 (ages 70–74 years), and 29.3 (ages 75–79 years) (5). The cost of treatment of these fractures is high, with the incremental cost of care after an osteoporotic hip fracture being $11,241 in the first year: together, the direct and indirect costs of osteoporosis amount to billions of dollars annually (2,6). What is more, when patients have a fragility fracture, their mortality rate increases dramatically: in one epidemiologic sample, such a fracture decreased 5-year survival from 76% to 61% (7). Even if patients survive, the fracture and its aftermath can precipitate the loss of their functional independence (1).

TREATMENT OF OSTEOPOROSIS

Despite these numbers, osteoporosis is treatable. Nearly anyone benefits from adhering to the daily allowances of calcium and vitamin D, in addition to sensible lifestyle recommendations such as exercise, smoking cessation, and the moderation of alcohol (8). Yet, when these recommendations are insufficient, various pharmacologic therapies are available, the mainstays of which are the bisphosphonates; alendronate therapy has been proven to decrease the risk of fractures in osteoporotic women and men (4,9,10). The efficacy of the bisphosphonates is also reasonable, with a meta-analysis indicating that only about 50–67 osteoporotic women would need to be treated for 1–3 years to prevent one hip fracture among them (the "number needed to treat"); moreover, perhaps, as few as 30 osteoporotic men might need to be treated to prevent a single vertebral fracture (11).

Nevertheless, the drugs used to treat osteoporosis are not entirely innocuous. Mild gastrointestinal symptoms from bisphosphonate therapy are quite common, affecting between one-tenth and a half of all patients (11). Fortunately, the more severe complications are exceedingly rare: for example, osteonecrosis of the jaw tends to occur only in the unusual

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setting of intravenous bisphosphonate therapy in the oncologic population (11). Moreover, the counterintuitive association of bisphosphonates with atypical subtrochanteric femoral fractures occurs in only 1 of every 1000 to 50,000 patients (11). Comparing the average of this estimate to the average number needed to treat for osteoporotic women suggests that bisphosphonate therapy would prevent about 400 hip fractures for every one subtrochanteric fracture that it caused.

Despite these favorable statistics, the use of bisphosphonates requires some judgment. Even from a purely economic perspective, foregoing screening and universally treating everyone at risk for developing osteoporosis might not be feasible: the cost of treating most of the elderly population could be just as expensive as managing just their fractures (3). That is, when pharmacotherapy is used, its initiation and choice must be individualized, with the future risk of a fragility fracture contributing to the treatment decisions.

Although fragility fractures are common, they do show heterogeneity in their prevalence, with the rate of hip fractures varying widely from region to region (3). Some trends in BMD correlate with demographic factors: for example, blacks have a higher average BMD than whites (2). Of course, it would be extraordinarily useful if we could accurately predict a patient's BMD solely on the basis of clinically apparent factors. However, although age, sex, weight, and race correlate with BMD, they do not do so strongly enough to allow treatment decisions to be made (2). Therefore, some direct measurement of BMD is ultimately necessary. Put another way, for a disease that is unpredictable, initially asymptomatic, morbid, yet potentially treatable, we would do well to deploy an effective screening examination.

DUAL-ENERGY X-RAY ABSORPTIOMETRY

Although many modalities can be used to detect BMD, the gold standard and the test most widely used in clinical practice is dual-energy x-ray absorptiometry (DXA). In this technology, the quantity of calcium within a bone is estimated using the differential absorption of two x-ray beams of different energies; as there is a strong correlation between this measurement and the strength of bone, DXA has come to be widely recognized as both the gold standard for determining BMD and a clinically useful surrogate for the risk of osteoporotic fractures (1,2,12). The raw data output by DXA scanners includes the calculated BMD, in units of g/cm^2 to emphasize that three-dimensional information has been projected into a two-dimensional measurement. Additionally, they provide comparative data, referencing the patient's BMD to a young white adult mean (T scores) and to a gender- and age-matched cohort (Z scores) in units of standard deviations from the mean (2).

Reporting these values is fairly uncontroversial: perhaps, it is not surprising then that many radiology reports stop at doing just that. Nevertheless, this is insufficient. The proper use of DXA in clinical practice requires vigilant attention to proper positioning, scan analysis, and interpretation (13). Common mistakes with these and other factors have been reviewed in detail elsewhere, but we will briefly explore how the interpretation of these numbers can be more nuanced than is frequently acknowledged (14).

CONTROVERSY AND CONFUSION IN DXA REPORTING

Osteoporosis is defined by the World Health Organization as a T score of -2.5 or less and osteopenia (or "low bone mass") as an intermediate category with T scores between -2.5 and -1.0. Although these criteria are generally accepted, they are arbitrary: choosing a more negative cutoff would categorize fewer patients as osteoporotic, whereas selecting a more positive one would generate many more with this disease (2). Because bone mineral densities vary in a continuous fashion, the creation of a discrete threshold for diagnosis may at first seem counterintuitive. Nevertheless, some objective boundary must exist for a diagnosis such as osteoporosis to have coherent meaning.

It has also been shown that the prevalence of osteoporosis varies greatly depending on the site of BMD measurement (15,16). That is, when measuring BMD from the spine and the hip, the World Health Organization diagnostic class may differ by one category in 42% of cases and by two categories in 4% of cases (16). Such discordance may reflect true spatial heterogeneity in a patient's bone structure or inaccuracies in the DXA measurement itself—such as the apparent increase of BMD in the spine that is caused by the presence of degenerative changes. This observation has led some to suggest that the T score cutoff of -2.5 should be adjusted depending on the site of measurement (15). Adding to the confusion, historically, some radiologists reported DXA scans as showing "osteopenia at the hip and osteoporosis at the spine." Instead, because osteoporosis is a systemic disease, the ISCD suggests that a single category should be issued based on the worst score from the lumbar spine, total hip, femoral neck, and occasionally the 33% radius (17).

Although the World Health Organization criteria for the diagnosis of osteoporosis were initially developed for postmenopausal women, it is clear that fragility fractures also occur in other populations. However, when BMD measurements are taken in a younger population—particularly in the pediatric age group—the results must be interpreted differently. In particular, diagnosis should be based on the deviation from a demographically matched cohort (Z score), rather than from the National Health and Nutrition Examination Survey (NHANES) III database (T score) (17). Nevertheless, the overdiagnosis and misdiagnosis of osteoporosis due to incorrect interpretation, most commonly the use of T scores in a young population, has been well documented (18). In fact, recommendations from the ISCD suggest that the term "osteoporosis" should not even be used in premenopausal women and in men aged <50 years: rather, referring to their BMD as "below the expected range for age" if their Z scores are at least two standard deviations below their cohorts' means (17).

Because the young adult database that underpins the calculation of T scores is referenced to Caucasians in the United States from the NHANES-III database, some studies have