Screening for poor bone mineral density using opportunistic foot radiographs: a retrospective cohort study

James Albright, Tyler A Martin, James David Baker, Matthew Feldman, Rutger Gunther, Kevin L Kirk, Jeannie Huh

INTRODUCTION:

In the United States, 54% of postmenopausal white women have low bone mass, and roughly another 20-30% have osteoporosis. Yet, many remain unaware of their condition and thus go untreated, resulting in rising rates of fragility fractures. By identifying patients with low bone mineral density (BMD), treatment can be initiated early, thereby decreasing the likelihood of fragility fractures and improving patient quality of life. The gold standard for low BMD screening is the dual-energy x-ray absorptiometry (DEXA) scan, which has dramatically decreased in use in recent years secondary to a multitude of reasons. This decline warrants identification of alternative screening mechanisms. This study aims to determine if opportunistic foot radiographs can serve as a screening tool for predicting low bone mineral density (BMD) as measured by DEXA scan.

METHODS:

All patients 50 years and older who underwent a DEXA scan between July 1, 2023 and July 1, 2024 were identified. Those who also underwent a foot radiograph within a year of their DEXA scan were selected to comprise the study group. Each foot radiograph was reviewed, and the fifth metatarsal cortical percentage (5MTP) was calculated at the distal extent of Zone 3 of the fifth metatarsal. This value was calculated by subtracting the isthmic diameter from the cortical diameter, dividing this value by the cortical diameter, and multiplying by 100 (**Figure 1**). The T-scores and BMD values were documented for each patient at the lumbar spine, bilateral femoral necks, and bilateral total femurs. Linear regression was used to determine a correlation between 5MTP and BMD of the femurs, hips, and spine, adjusting for age. Multivariable logistic regression models were used to determine the 5MTP between those with osteoporosis and osteopenia in the femur, hip, and spine. Receiver-Operator-Characteristics (ROC) curves were generated, and areas under the curves (AUC) were calculated to determine what 5MTP had the best sensitivity and specificity to differentiate normal, osteopenic, and osteoporotic BMD values.

RESULTS:

A total of 75 patients were included in the study cohort. The average age of the patient population was 69.9 ± 9.7 years, and 74.7% were women. The 5MTP was positively correlated with the BMD of both the femoral neck and the total femur. For every unit increase in 5MTP, the average BMD of both the femoral neck and total femur increased by 0.008 g/cm^3 ($p < 0.001$ for both). The optimal 5MTP for determining osteopenia and osteoporosis in the femoral neck was 42.8% and 42.6%, and these correlated with AUC of 0.727 and 0.838, respectively (Figure 2). Figure 3 demonstrates the interquartile ranges of 5MTPs in patients with normal BMD, osteopenia, and osteoporosis with the plotted optimal cutoffs. The sensitivity and specificity for correctly identifying and ruling out osteopenia in the femoral neck were 47.4% and 94.4%, respectively ($p = 0.004$). Similarly, the optimal cutoff for identifying osteoporosis in the femoral neck had a sensitivity of 58.3% and a specificity of 94.4% ($p = 0.002$).

For the total femur, the optimal 5MTP for determining osteopenia and osteoporosis was 39.6 and 38.8, and these correlated to AUC of 0.757 and 0.879, respectively (Figure 4). Figure 5 demonstrates the interquartile ranges of 5MTPs in patients with normal BMD, osteopenia, and osteoporosis with the plotted optimal cutoffs. The sensitivity and specificity for correctly identifying and ruling out osteopenia in the total femur were 40.5% and 97.0%, respectively ($p < 0.001$). Similarly, the optimal cutoff for identifying osteoporosis in the total femur had a sensitivity of 60.0% and a specificity of 97.0% ($p < 0.001$).

DISCUSSION AND CONCLUSION:

This study describes a potential screening method of using low-cost foot radiographs to assist in identifying patients with low BMD, to increase the detection and treatment of low BMD and associated fragility fractures. We propose cutoff values for the fifth metatarsal cortical percentage (5MTP) that maximize the specificity and sensitivity for identifying patients with osteopenia and osteoporosis.