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Fractal Analysis of Radiographic Trabecular Bone Texture and Bone Mineral Density: Two Complementary Parameters Related to Osteoporotic Fractures

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ABSTRACT

Trabecular bone microarchitecture and bone mineral density (BMD) are two main factors related to osteoporotic fractures. Currently, however, microarchitecture is not evaluated. We have developed and validated a trabecular bone texture analysis from radiographic images. The objective was to determine if the fractal analysis of texture was able to distinguish osteoporotic fracture groups from control groups, either in vertebrae, hip, or wrist fractures, and to determine if this indicator and BMD were independent and complementary. In this cross-sectional unicenter case-control population study in postmenopausal women, 107 fracture cases were enrolled and age-matched with 197 control cases. This population comprised 40 vertebral fractures (with 70 controls), 30 hip fractures (55 controls), and 37 wrist fractures (62 controls). Hip and lumbar spine BMD were measured by double-energy X-ray absorptiometry. Fractal analysis of texture was performed on calcaneus radiographs and the result was expressed as the H parameter (H = 2-fractal dimension). The H parameter showed a lower value (0.679 ± 0.053 SD) in fracture cases versus control cases (0.696 ± 0.030; $p = 0.007$), the statistical significance persisting after adjustment for age and for lumbar spine (LS) or hip BMD. This result was confirmed in vertebral fractures ($p = 0.0001$) and hip fractures ($p = 0.003$) but not wrist fractures ($p = 0.07$). We determined the threshold between high and low H values and then the odds ratios (OR) of fracture for low H for BMD ≤ -2.5 SD in T score and for the combinations of both parameters. The OR of fracture for low H was 1.6 (95% CI, 1.1–2.6). For LS BMD ≤ -2.5 SD the OR of 6.1 (3.4–10.8) shifted to 9.0 (4.0–20.4) when we added low H and for hip BMD it shifted from 5.6 (3.3–9.4) to 8.1 (4.0–16.8). In vertebral, hip, and wrist fracture cases the results were also significant. These data have shown that the fractal analysis of texture on calcaneus radiographs can distinguish osteoporotic fracture groups from control groups. This analysis and BMD provide independent and complementary information. These data suggest that we can improve the fracture risk evaluation by adding information related to microarchitecture, derived from analysis of conventional radiographic images. (J Bone Miner Res 2001;16:697–704)

Key words: fractal analysis, bone mineral density, osteoporotic fractures, trabecular bone microarchitecture, texture analysis