The Relationship Between Clinically Available Techniques for Assessment of Skeletal Status of the Forearm and Failure Load of the Distal Radius

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Among osteoporotic fractures, distal radius fractures occur first. It is therefore important to identify risk factors associated with reduced radial bone strength. The purpose of this study was to determine the relationship between several clinically assessed bone parameters and the load required to fracture the distal radius in a configuration simulating a fall on the outstretched hand. Thirty-eight left forearm specimens with intact soft-tissues were obtained from 18 female and 20 male cadavers (mean age = 78±12 yrs, range = 53-97). Bone mineral content (BMC, g) and areal density (BMD, g/cm^2) of the radius at the ultradistal (UD) and 1/3 distal regions was measured using DXA (Hologic QDR2000+). Digital x-ray radiogrammetry was used to estimate BMD of the forearm (DXR-BMD, Pronosco). Volumetric bone density (BD, mg/cm^3), mineral content (CNT, mg), and cross-sectional area (CSA, mm^2) of the trabecular, cortical and total (trabecular + cortical) regions were assessed at the 4% distal site of the radius using pQCT (Stratec 960A). BMD of the middle phalanx of the 2nd and 4th fingers (phBMD, g/cm^2) was assessed using dual-energy radiographic absorptiometry (Schick accuDEXA). After heating the forearms to 37^{o}C, ultrasound velocity (UVrad, m/s) at the distal radius was assessed using the Sunlight Omnisense device. Finally the radii were excised from the forearm and cut 3" proximal to the 25% site of the distal radius. The proximal and distal ends of the radii were embedded in polymethylmethacrylate. To simulate a fall on an outstretched hand, the radii were positioned 15° back from the vertical and a compressive load was applied at a displacement rate of 100 mm/sec. Twenty-four specimens met our inclusion criteria for distal radius fracture (10 F, 14 M, mean age 76±13 yrs). Bivariate regression analysis was performed to assess the relationship between these bone parameters and failure load of the distal radius. Radius BMC (r^2=0.53-0.69) and BMD (r^2=0.45-0.50) were moderately to strongly correlated to failure load, with UD-BMC having the highest correlation. CNT (r^2=0.41-0.61), phBMD (r^2=0.59) and DXR-BMD (r^2=0.47) were also moderately to strongly correlated with failure load. In contrast, volumetric bone density (r^2=0.30-0.35), pQCT-derived cross-sectional geometry (r^2=0.01-0.29), and UVrad (r^2=0.37) were only moderately to weakly correlated to failure load. In conclusion, BMC measurements of the radius performed by DXA or pQCT, and BMD of the phalanges measured by accuDEXA, were better at predicting radial failure load than ultrasound SOS or geometric parameters measured by pQCT. Specifically, BMC as measured by forearm DXA, accounts for nearly 70% of the failure load of the distal radius assessed in a fall configuration. In general, measurements of bone mineral content were better than bone mineral density in predicting failure load of the distal radius.

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