
We tested the hypothesis that bone mineral density (BMD) and bone mineral content (BMC) in proximal human femur specimens in the upper neck region of interest (ROI) and femoral neck axis length (FNAL) provide a significantly better prediction of femoral bone strength than standard ROIs in vitro. BMD and BMC were measured in 110 proximal femur specimens using a standard dual-energy X-ray absorptiometry (DXA) scanner. The analysis included a new ROI in the upper neck as well as the standard ROIs. FNAL was obtained from the scan images. The specimens’ failure-load was measured in a mechanical loading device, simulating a fall on the greater trochanter. For the standard ROIs, correlations between failure-load and BMD ranged from $R^2 = 0.64$ (shaft ROI) to $R^2 = 0.70$, $p<0.001$ (femoral neck). Prediction of strength by BMD did not significantly differ from those of BMC ($R^2$ ranging from 0.65 to 0.75, $p<0.001$). In the upper neck ROI, for both BMD and BMC correlations with failure-load were higher ($R^2 = 0.76$ and 0.81, respectively; $p<0.001$). A lower, yet still significant, correlation was found between FNAL and bone strength ($R^2 = 0.23$, $p<0.001$). Normalization of failure-load with respect to FNAL did not significantly increase the correlations with densitometric measures. This study provides in vitro evidence indicating
that among the ROIs of the proximal femur the newly defined upper neck ROI provides the best prediction of bone strength. Only a weak association was observed between failure load and FNAL.