Estimation of wrist fracture load using phalangeal speed of sound: an in vitro study

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This study aimed to evaluate the ability of speed of sound (SOS) measured at the phalanges to estimate simulated wrist fracture load and stress. SOS was measured along the proximal phalanges of the second, third and fourth fingers using an ultrasound (US) system operating in axial transmission mode. The bone mineral density (BMD) of the radius and the phalanges was also measured with quantitative computed tomography (QCT) and dual x-ray absorptiometry (DXA), and the combined cortical thickness (CCT) of the phalanges was measured from hand radiographs. After the measurements were completed, the radius was excised from the cadaver, embedded in polymethylmethacrylate and tested to failure on a servohydraulic testing machine. The configuration of the radius was chosen to simulate a fall onto the hand. Linear regression analysis showed a highly significant correlation between SOS ($r = 0.76$-0.94, $p < 0.001$), CCT ($r = 0.86$-0.90, $p < 0.001$) and BMD ($r = 0.92$-0.96, $p < 0.0001$) in the three proximal phalanges measured. SOS, BMD and CCT were significant predictors of fracture load ($r = 0.60$-0.69, $p < 0.03$) and stress ($r = 0.65$-0.77, $p < 0.02$). Cortical area and bone mineral content (BMC) of the radius were consistently higher predictors of fracture load ($r = 0.76$-0.82, $p < 0.01$ for area and $r = 0.78$-0.88, $p < 0.01$ for BMC) than BMD. The correlation of BMC and area was poorer with fracture stress. In a step-wise regression analysis using both phalangeal BMD and SOS, only SOS remained a significant predictor of fracture stress. In forward stepwise regression analysis, both cortical area and SOS were entered into the regression model to estimate fracture load. Only SOS remained significant in the model for estimating fracture stress. Phalangeal BMD was only entered in the combined model with the cortical area at the 4% site ($r = 0.84$, $p = 0.002$). Phalangeal SOS is a useful parameter in the assessment of bone status of the radius.

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