Multiparametric Imaging of Bone Architecture: a Cadaveric Study

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Introduction: Since osteoporosis is a systemic disease, it might be assumed to have similar degenerative effects on microarchitecture across osseous sites. Architectural measurements from the appendicular skeleton, such as the distal radius, which are more easily obtained in vivo, could then be used as surrogate markers of axial skeletal architecture. The hypotheses tested include: 1) the presence of vertebral fractures will correlate negatively with vertebral strength and 2) the microarchitecture of the distal radius and vertebral bodies will correlate with vertebral strength.

Methods: Subjects: Five cadavers donated for medical science research were studied, after formalin fixation. Thoracic and lumbar vertebrae were dissected in each cadaver and used in image analysis and strength testing. QCT, μCT, and destructive testing were completed for each specimen. Mixed effect models were used to compare strength measures and SDI. Mixed linear models with a random effect were used to assess relationships between strength measures and architectural measures, using a random effect to account for within subject correlation of repeated observations.

Results: Three of 5 subjects had minor/moderate fractures (with SDI = 1.5, 2 and 3 respectively) and 2 others had severe fracture (both with SDI=14). Mean ± SE of vertebral strength was 220.9 ± 19.3 (lb/in^2) for minor/moderate fracture cases and 92.1 ± 22.0 lb/in^2 for severe fracture cases respectively (p=0.001). Strength was positively correlated with BV/TV and Conn Dens with slope ± SE's being 17.7 ± 7.1 (p=0.033) and 89.6 ± 29.2 ($1/mm^3$) (p=0.012); and negatively correlated with SMI and Star volume with slope ± SE's being -90.4 ± 31.7 (p=0.017) and -0.99 ± 0.3 mm^3(p=0.003) respectively. When strength and BMD were compared, the relationship was not significant with slope ± SE being 0.38 ± 0.32 and a p=0.261. Finally, weak correlation was demonstrated when comparing the strength measures from the vertebrae to architectural measures from the radius (p's >.05).

Discussion: As hypothesized, there was a very high correlation between prevalent vertebral fractures and decreased vertebral strength. Vertebral architecture was a much better predictor of vertebral strength than distal radius microarchitecture, which was only weakly correlated. An increase in sample size is needed to further validate these results as a small sample size is a limitation of this study.