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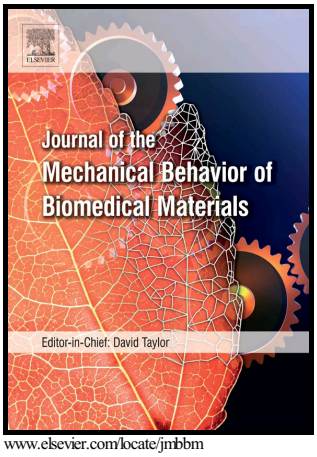

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Dehydration of individual bovine trabeculae causes transition from ductile to quasi-brittle failure mode

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Abstract

Trabecular bone is located inside flat bones as well as in the epi- and metaphysis of long bones and plays a key role with respect to load transfer. Disorders, such as osteoporosis, weaken the structural integrity and may also cause changes in the mechanical properties of individual trabeculae, such as Young's modulus. Knowledge of mechanical tissue properties are necessary to assess risk of bone fracture with finite element analysis (FEA). However, such parameters are most often obtained from experiments on air-dried specimens which do not reflect the physiological conditions. In this study, micro-tensile tests of individual bovine trabeculae were performed until fracture to evaluate the influence of hydration state on the elastic and post-yield behavior. Dehydration resulted in significantly ($p < 0.001$) lower post yield work and ultimate strain, whereas stiffness, yield stress and ultimate stress were significantly ($p < 0.001$) larger. Further, inelastic strain of dehydrated samples was confined to a small region, whereas it was distributed over a larger area in wet samples. Similarly, microdamage accumulation was confined to a significantly smaller region ($p < 0.05$) in dry samples, compared to wet ones. Thus, damage localization resulted in a quasi-brittle failure in dry samples. In contrast, hydrated samples showed a much larger