THE ROLE OF DAMAGE MORPHOLOGY IN AGE-RELATED INCREASE IN BONE FRAGILITY

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ABSTRACT

Age-related fractures are a major health problem in the elderly. Traditionally, only bone density has been considered to predict fracture risk but several recent studies have shown that other factors including microdamage may contribute to bone fragility.

In vivo microdamage occurs in two forms, linear microcracks and diffuse damage. In this study, the role of damage morphology, produced during fracture, in the age-related increase in bone fragility was investigated. Cortical bone beam specimens were subjected to in vitro four-point bending fatigue, followed by histological or mechanical assessment of microdamage and micromechanical modeling. The results show that the formation of diffuse damage occurs at an early stage while the formation of linear microcracks occurs towards the end of the fatigue life. Young donors show a tendency to form diffuse damage that is self-limiting, takes time to form and dissipates more energy by causing a greater loss of local stiffness and forming in less mineralized areas. In contrast, older donors demonstrate a higher propensity of forming linear microcracks that are associated with limited stiffness loss, high tissue mineralization and brittle fracture.

Consistent with the in vitro results, measurement and analysis of in vivo microdamage showed dimorphic association between microdamage morphology and age. Furthermore, in vivo microdamage had no correlation with bone geometry parameters and exhibited distinct preferences with bone microstructure. Linear microcracks formed in interstitial bone and were trapped by microstructural interfaces.

Areas of diffuse damage were preferentially associated with secondary osteonal bone and had no relationship with microstructural interfaces.

In conclusion, this study presents a novel microdamage morphology based mechanism of fracture resistance in bone and identifies the contributing bone quality features that are subjected to change with age and increase propensity of bone fracture in the elderly.