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Experimental Research on the Elastic Modulus of Bones at the Lamellar Level under Fatigue Loading

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Abstract : Compact bone produces fatigue damage under the inevitable physiological load. The accumulation of fatigue damage can change the bone's micro-structure at different scales and cause the catastrophic failure eventually. However, most tests were limited to the macroscopic modulus of bone and there is a need to assess the microscopic modulus during fatigue progress. In this paper, nano-identation was used to investigate the bone specimen subjected to four point bending. The microscopic modulus of the same area were measured at different degrees of damage including fracture. So microscopic damage can be divided into three stages: first, the modulus decreased rapidly and then They fell slowly, before fracture the decline became fast again. After fracture, the average modulus decreased by 20%. The results of inner and outer planes explained the influence of compressive and tensile loads on modulus. Both the compressive and tensile moduli decreased with the accumulation of damage. They reached the minimum at ending and increased after fracture. The modulus evolution under different strains were revealed by the side. They all fell slowly and then fast with the accumulation of damage. The fractured results indicated that the elastic modulus decreased obviously at the high strain while decreased less at the low strain. During the fatigue progress, there was a significant difference in modulus at low degree of damage. However, the dispersed modulus tended to be similar at high degree of damage, but they became different again after the failure.

Keywords : fatigue damage, fracture, microscopic modulus, bone, nano-identation
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