ROBERT R. McCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

LECTURES

THE 2007 DOW LECTURE
in
MATERIALS SCIENCE AND ENGINEERING

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Aging and Disease and the Fracture of Bone: An Issue of Quality vs. Quantity?

The age-related deterioration of the architecture of bone and its fracture properties, coupled with increased life expectancy, are responsible for increasing incidences of bone fractures in the elderly segment of the population. Currently, opinion is divided as to whether this is principally an issue of a loss of bone mass (or bone mineral density), termed *bone quantity*, or one associated with *bone quality* involving its inherent material properties. In order to facilitate the development of effective treatments that counter the elevation of the fracture risk, an understanding of how fracture properties degrade with age is essential. In this talk, the origins of the toughness of human cortical bone (and dentin, a primary constituent of teeth and simple analog of bone) are examined from a materials science viewpoint by considering the salient micro-mechanisms of failure over a broad range of characteristic dimensions from molecular to macroscopic length-scales. It is argued that although structure at the nanoscale is important, it is microstructural features at the scale of one to hundreds of microns that are critical in determining fracture risk.[1] It is further shown that biological aging, certain disease states and therapeutic treatments (such as steroids), can cause a marked deterioration in bone quality which raises this fracture risk, principally by affecting the toughening mechanisms over a broad range of dimensions.

[1] R. K. Nalla, J. H. Kinney, and R. O. Ritchie, *Nature Materials*, **2**, 164 (2003)

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