SMALL SCALE FRACTURE OF BONE TO UNDERSTAND THE EFFECT OF FIBRILLAR ORGANIZATION ON TOUGHNESS

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Fracture toughness is a critical component of bone quality and derives from the hierarchical arrangement of collagen and mineral from the molecular level to the whole bone level. Molecular defects, disease, and age affect bone toughness, yet there is currently no treatment to address deficits in toughness. Toughening mechanisms occur at every length scale, making it difficult to isolate the influence of specific components. Most experimental studies on the fracture behaviour of bone use milled samples of bone or whole bones. Toughness deficits can be identified but may be caused by a multitude of parameters across length-scales, making it difficult to develop targeted therapies. Herein, we measure the toughness of bone in micropillars where porosity and heterogeneities are minimized, allowing us to determine the role of fibril anisotropy on fracture toughness. Double cantilever beam micromechanical tests were conducted in a scanning electron microscope on 4x6x15 mm pillars of mouse bone femorae produced in the longitudinal and transverse orientations. Subsequent transmission electron microscopy of the fractured pillars revealed a role of the local organization of the mineralized collagen fibrils in influencing crack propagation. We demonstrate that fibril orientation is a critical factor in deflection during crack propagation, significantly contributing to fracture toughness.