Research paper

Effects of osteoporosis and nutrition supplements on structures and nanomechanical properties of bone tissue

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A B S T R A C T

In this study, the bone structures, nanomechanical properties and fracture behaviors in different groups of female C57BL/6 mice (control, sham operated, ovariectomized, casein supplemented, and fermented milk supplemented) were examined by micro-computed tomography, scanning and transmission electron microscopy, and nanoindentation. The control and sham operated mice showed dense bone structures with high cortical bone mineral densities of 544 mg/cm\textsuperscript{3} (average) and high hardness of 0.9–1.1 GPa; resistance to bone fracture was conferred by microcracking, crack deflections and ligament bridging attributed to aligned collagen fibers and densely packed hydroxyapatite crystals. Bone mineral density, hardness and fracture resistance in ovariectomized mice markedly dropped due to loose bone structure with randomly distributed collagens and hydroxyapatites. The acidic casein supplemented mice with blood acidosis exhibited poor mineral absorption and loose bone structure, whereas the neutralized casein or fermented milk supplemented mice were resistant to osteoporosis and had high bone mechanical properties.

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1. Introduction

Bone tissue, which is a complex and hierarchical tissue with high strength and toughness, is built by different levels of structures, from macroscale cortical and trabecular bone, microscale Haversian osteon and lamellae, to nanoscale hydroxyapatite crystals and collagen fibers (Junqueira et al., 1993; John and Gartland, 1993; Riggs and Melton, 1993; Ager Jr. et al., 2006; Sahara et al., 2005; Rubin et al., 2003; Rubin and Jasiuk, 2005). From an elemental perspective, bone is composed of about 35 wt% organics, mainly type I collagens, and 65 wt% inorganics, i.e. minerals (mostly calcium phosphate) (Junqueira et al., 1993; John and Gartland, 1993; Riggs and Melton, 1993; Dorozhkin and Epple, 2002). How bone tissue, a perfect natural composite material, combines the high strength of hard minerals and the toughness of...