

Bone Microdamage and Bone Quality

Logan K Burgess¹, Hartmut Malluche², Constance Wood³, David Pienkowski⁴

¹University of Kentucky College of Medicine, Lexington, KY

²Department of Medicine/Nephrology, University of Kentucky, Lexington, KY

³Statistics Department, University of Kentucky, Lexington, KY

⁴Department of Biomedical Engineering, University of Kentucky, Lexington, KY

Abstract

Introduction: Fracture thresholds are known for most adult bones; current methods for calculating adjustments are based upon variations in bone quantity. Bone quantity is commonly measured via bone mineral density. When fractures occur at forces substantially less than threshold values, the purported injury mechanism may be questioned. Bone quality governs fracture thresholds and is determined by several factors, one of which (seldom explored) is microdamage. The purpose of the present study was to investigate the type and extent of microdamage in low and non-low turnover bone.

Methods: One in ten Americans has some form of kidney disease. Chronic kidney disease (CKD) sufferers have an overall bone fracture rate considerably greater than the normal population, especially those on dialysis. Variations in bone turnover are observed in CKD patients. For these reasons, this patient population was chosen for the present IRB approved study. Men and non-Caucasians were excluded to focus on the CKD patient subpopulation with the highest fracture risk.

Bone samples were obtained from iliac crest biopsies from fourteen of these patients. Samples were sectioned, stained, and histologically analyzed. Seven patients had low bone turnover; seven patients had non-low bone turnover. Samples were examined under brightfield and fluorescence microscopy and histomorphometric software was used for microdamage assessments.

Microcracks in the trabecular compartment of these samples were identified by depth of field, presence of a 'halo' stain in crack walls, and linear presentation. Features initially resembling cracks but lacking these attributes were ignored. Fifty optical fields were examined for each bone sample. Parameters measured included: bone area and perimeter, crack length, and crack number. Customary parametric statistical analytical techniques were employed.

Results: Bone samples from patients with low turnover had 2.45 times more ($p < .02$) microcracks per mm^2 of bone than bone samples from patients with non-low bone turnover. Also,

total crack length per mm² of bone was 2.84 times greater ($p < .03$) in the non-low turnover group compared to the low turnover group.

Discussion: Patients with CKD and low bone turnover have a greater quantity and severity of bone microdamage than CKD patients with non-low bone turnover. Abnormalities in mineral composition, bone volume, and bone matrix have all been previously associated with diminished bone quality. This study adds abnormalities in microdamage to the list of components that must be considered in the pathogenesis of fractures. Examination of bone quality may provide useful insights regarding the mechanism behind reductions in load-bearing capability and fracture threshold. These preliminary findings await additional studies to compare clinical fractures with bone turnover rate and microdamage levels.