

Introduction

Fracture thresholds are known for most adult bones and are used for assessing injury probability. Current methods for calculating adjustments to these thresholds are based upon bone quantity (measured via bone mineral density, BMD). When fractures occur at forces substantially less than threshold values, the purported injury mechanism may be questioned, particularly when BMD is not abnormal. Bone quality extends BMD to include other 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

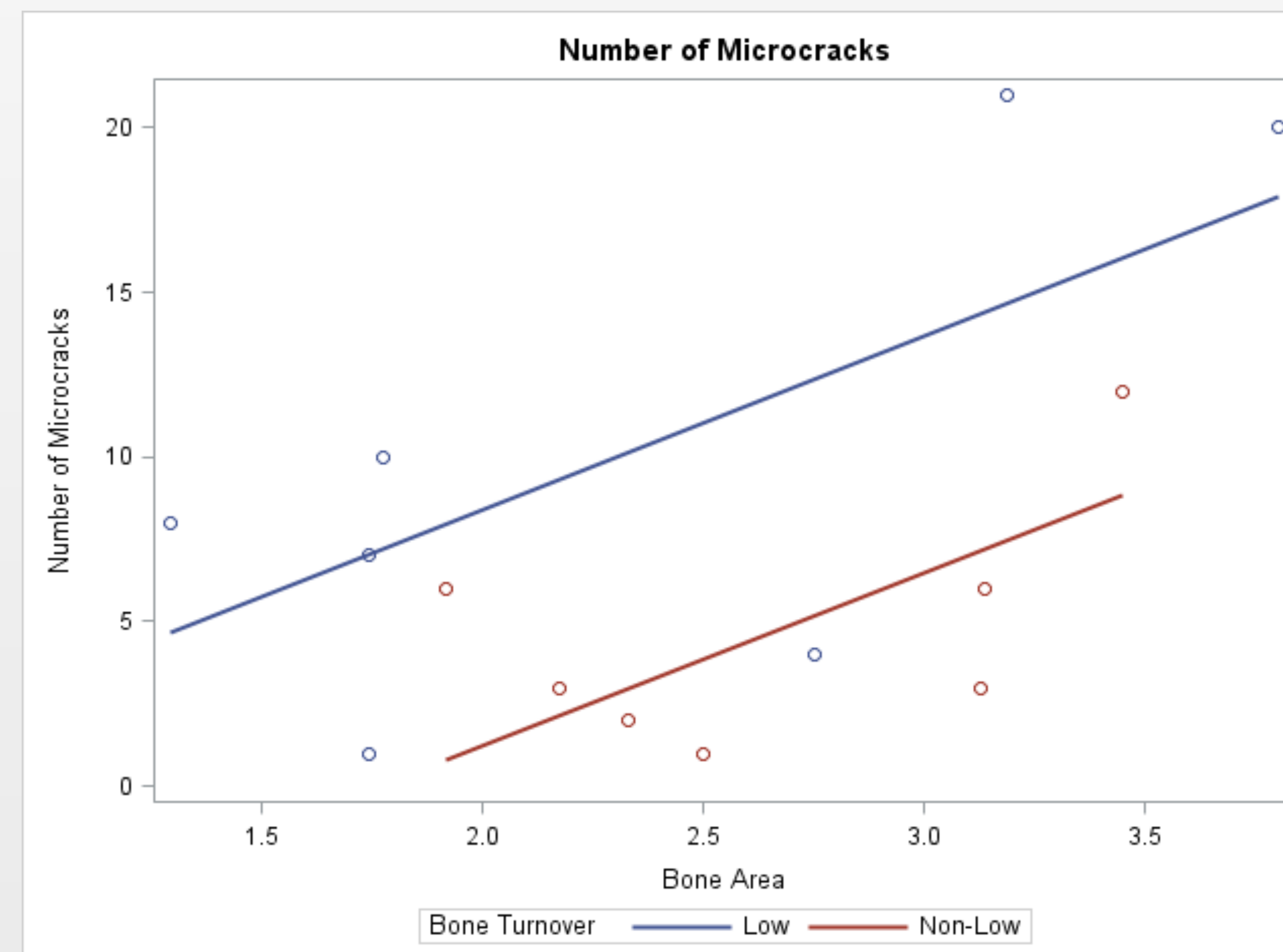
Bone samples were obtained from iliac crest biopsies from fourteen patients diagnosed with chronic kidney disease (CKD) in this IRB-approved study. Seven patients had low bone turnover; seven patients had non-low bone turnover. Samples were sectioned, stained, and histologically analyzed. Samples were 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: a) depth of field, b) presence of a 'halo' stain in the observed microcrack walls, and c) linear microcrack morphology. Features initially resembling cracks but lacking these attributes were ignored. Fifty optical fields in each bone sample were examined. Parameters measured were: bone area and perimeter, crack length, and crack number. Data were analyzed by using analyses of covariance.

Results

After adjusting for bone area (B.Ar), bone samples from patients with CKD and low turnover had 2.15 times more ($p < 0.02$) microcracks per mm^2 of bone than bone samples from patients with CKD and non-low bone turnover. Also, total crack length per mm^2 of bone was 2.62 times greater ($p < 0.03$) in the low turnover group compared to the non-low turnover group.

Number of Microcracks (Cr. N)



Discussion

The key finding of this study is that bone with low turnover from patients with chronic kidney disease has a greater quantity and severity of microdamage than bone with non-low turnover from the same patient population. This is a new finding previously undocumented in the literature. It adds to our understanding of the effects of bone turnover abnormalities and their relationship with bone quality, specifically microdamage.

- This finding is important because one in ten Americans has some degree of kidney disease; this population incurs bone fractures more than 4 times the rate of the normal population. Although this study was limited to bone turnover variations associated with CKD, bone turnover abnormalities attributable to other pathologies may also be associated with abnormally high microcrack numbers or lengths. Microdamage assessments in such patient populations is warranted by the present study.

Conclusion

Increased levels of microdamage are observed in patients with chronic kidney disease and low bone turnover. Increased microdamage results in reduced bone quality and diminished mechanical competence. Since the early stages of chronic kidney disease are often undiagnosed, the present findings may provide evidence explaining why some fractures occur at sub-normal thresholds. This study adds microdamage to the list of bone quality factors that must be considered in the pathogenesis of fractures, especially those occurring at low-energy levels. These preliminary findings await additional studies to compare clinical fractures with bone turnover rate and microdamage levels.

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