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BONE LOSS ASSESSMENT AND GUIDED THERAPY FOR FRACTURE HEALING USING  
QUANTITATIVE ULTRASOUND**Abstract**

Microgravity affects bone mineral density, microstructure and integrity, which lead to the risk of osteoporosis and fracture. Quantitative ultrasound (QUS) provide a unique method for evaluating both bone strength and density, particularly under the extreme condition like long-term space mission. The objective of this study has two folds, 1) to evaluate the efficacy of a scanning confocal acoustic navigation (SCAN) QUS system for bone quality and fracture assessment in localized interested region; and 2) to test a QUS guided ultrasound in acceleration of fracture healing in a hindlimb suspension (HLS) model. QUS was processed to calculate the ultrasound attenuation (ATT; dB), wave ultrasound velocity (UV), and the broadband ultrasound attenuation (BUA; dB/MHz). Both QUS measurements was conducted in the region of interests covering an approximate 60x60 mm<sup>2</sup> with 0.5 mm resolution. Total of 36, 5-month old Sprague-Dawley rats were divided into six groups including 1) fracture control (FC, n=12), 2) fracture with HLS (FS, n=12), and 3) fracture with HLS, plus QUS treatment (FSU, n=12). Standard fractures were performed at the middle of left femur of each animal with HLS. Guided QUS was delivered transversally at the femur, 20 min/day, 5 days/wk for 5 weeks. Hindlimb bones were imaged using microCT at 18 micron at week 1, 3, and 5 in the callus, with Mechanical testing. In the week 1 and 3, there were no significant difference between control and HLS, and between QUS treated and untreated. However, in week 5, BVF in fracture with HLS (0.19+/-0.05) showed -6% lower than normal fracture (0.21+/-0.05), while QUS treated (0.27+/-0.06) was 30% increase than the fracture control (p<0.05). In the 4-pt bending biomechanical testing, there was no significant difference between normal fracture and fracture with HLS. However, the bone stiffness in QUS treated fracture in HLS was 48% higher than untreated HLS fracture (p<0.05). It has been demonstrated that the in vivo assessment of bone quality using SCAN predicts overall BMD distributions in the region of interests, and capable to identify fracture. Guided ultrasound treatment develops the best callus mineralization quality, which is over 48% better than normal and HLS groups, indicating QUS can enhance healing under disuse condition, and promote the bone mineralization.