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Fracture and bone defect assessment using quantitative ultrasound wave propagation

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Nondestructive evaluation of early fracture and monitoring its healing, particularly in non-typical fracture, is critical yet challenge. Quantitative ultrasound test along the long bone is largely dependant on bone density, gap size, the level of maturity of the callus, and mineralized status. We propose that the ultrasonic velocity (UV) is dependent on fracture gap size and the degree of porosity. The objective of the study was to develop an analytical and a multiple ultrasound sensing system for non-invasive fracture assessment. An analytical model was generated as a function between UV and the gap size in long bone. The ultrasound measurements were performed in the intact pig femur with controlled fracture sizes, e.g., 1mm, 3mm and 5mm. A serial ultrasound transducers were aligned 3 cm above bone with an angle approximately equal to the critical angle. The results indicated that the UV decreased with increase of fracture size in a linear manner (r=0.96), in which UV decreased 6.7%, 16.3% and 26.8% for 1, 3 and 5 mm gaps, respectively. The simulation result significantly matched the experiment measurement (r=0.98). The results demonstrated that quantitative ultrasound has potential to the diagnosis of fracture, monitoring fracture healing, and other bone disorders.