A NEW DUAL-MODE ULTRASONIC TECHNIQUE FOR ASSESSING CORTICAL BONE

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Osteoporotic fractures are a major public health problem; diagnosis is based on x-ray densitometry (DXA); however, DXA is not able to accurately predict who will and will not suffer a fracture. An alternative to DXA is ultrasound, which is viewed as having the potential to better characterize fracture risk. Our approach is based on “dual-mode” ultrasound in which two distinct modes are used together to assess cortical bone. In particular, measurements are made at the mid-shaft tibia in both axial-transmission and pulse-echo modes. Axial transit time (τ_a) and pulse-echo transit time ($\tau_{P/E}$) are obtained at the same tibial cortical site. These two transit times can be used in a classification scheme to identify individuals at greatest risk of fragility fracture. A typical pulse-echo signal is shown in Fig. 1; as may be seen the periosteal and endosteal signals can be readily identified, and an estimate of the pulse-echo time delay, $\tau_{P/E}$, can be obtained. A typical axial-transmission signal is shown in Fig. 2; as may be seen the signals measured at two receivers can be identified and the axial transit time, τ_a, as well as the axial ultrasound velocity, v_a, can be obtained. A pilot set of measurements on 11 individuals has been carried out to demonstrate the basic feasibility of the proposed technology. For the 11 subjects (demographic data provided in the Table), each subject data point was found to be in a distinct region (i.e., a hypothesized distinct bone quality state) of the quadrant associated with the two transit times, or equivalently with $\tau_{P/E}$ and v_a. Because the two parameters are each affected in distinct fashions by a variety of bone quality factors (such as degree of mineralization, porosity, cortical thickness, and biomechanical stiffness), the bivariate feature has the potential to accurately identify those individuals at increased risk of fracture. Further studies on individuals with and without fragility fractures will elucidate the capabilities and potential of the dual-mode ultrasound technology proposed here.

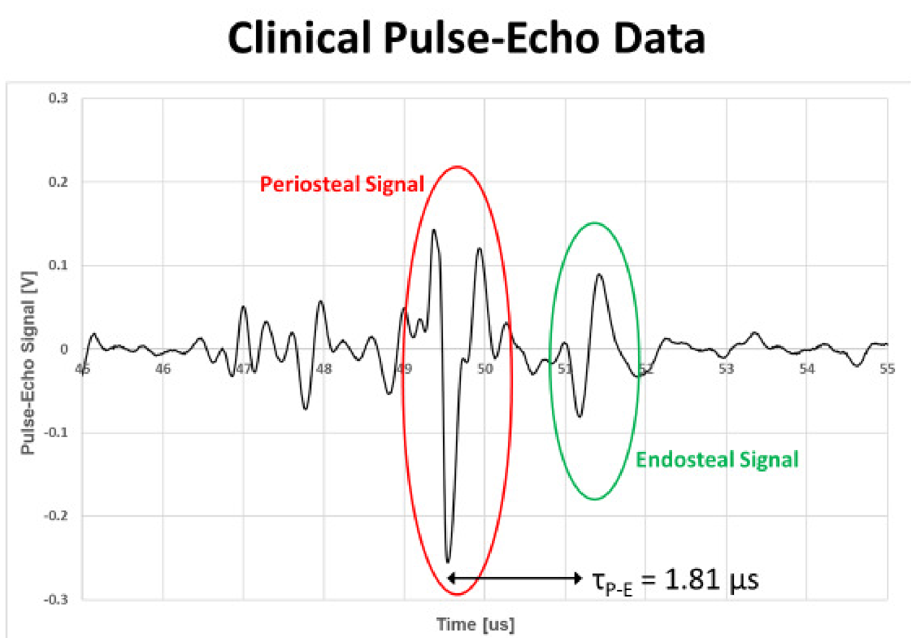

Fig. 1. Clinical pulse-echo ultrasound signal at the mid-shaft tibia.

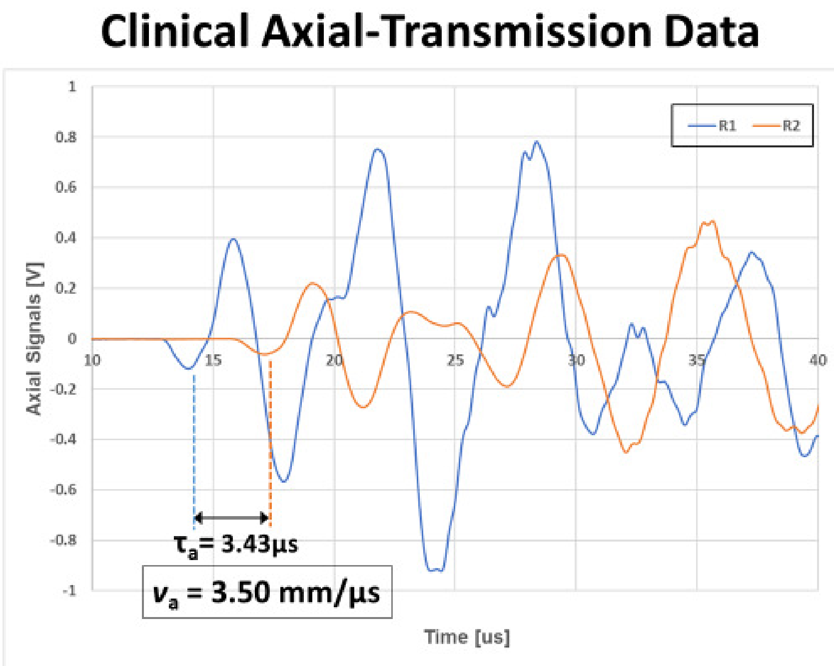

Fig. 2. Clinical axial-transmission ultrasound signal at the mid-shaft tibia.

Table

N = 11 (Number of subjects)	**Mean (SD)**	**Min-Max**
Age [Years]	46 (17)	21-72
Race 91% White 9% Asian		
Sex (46% female)		
Height [cm]	162 (9)	150-175
Weight [kg]	59 (11)	47-77
τ_{P-E} [µs]	1.49 (0.46)	0.82-2.42
v_A [mm/µs]	3.47 (0.13)	3.28 – 3.70

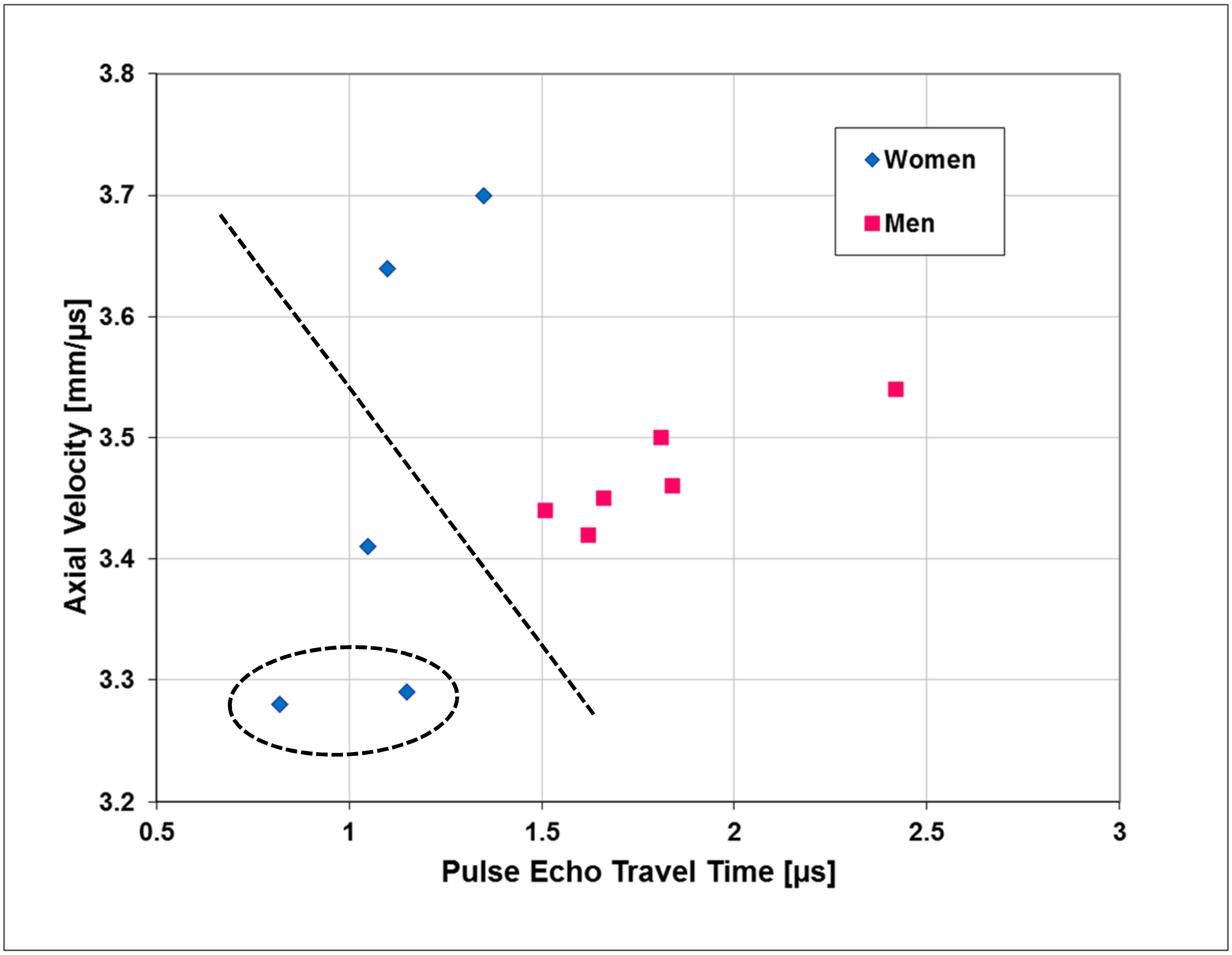

Fig. 3. Results for the 11 study subjects. The two subjects enclosed by the dashed ellipse were both diagnosed as osteoporotic and one of them (the one with the smaller pulse-echo travel time) also had a fragility fracture. The dashed line indicates a proposed pattern classification approach to being better able to identify those individuals at increased risk for fracture.