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CALIBRATION AND QUALITY ASSURANCE PROCEDURES FOR THE ULTRASONIC ASSESSMENT OF OSTEOPOROSIS

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1. ULTRASONIC ASSESSMENT OF OSTEOPOROSIS

There is increasing interest in assessing the role of ultrasound to identify and monitor osteoporosis, the loss of bone resulting in an increased risk of fracture, particularly of the wrist, vertebrae and hip in women. Measurements of ultrasound velocity and broadband ultrasonic attenuation (BUA) are generally performed through the calcaneus in the heel.

To date, three commercial ultrasound systems have been developed incorporating either immersion or direct contact transmission techniques. Comparative studies have highlighted that the data obtained from these systems are highly correlated but not identical, primarily because of differences in anatomical positioning and data analysis algorithms.

2. CALIBRATION: ELECTRONIC BONE PHANTOM

Although there are several materials which may be implemented to ensure calibration for ultrasound velocity, it has been impossible to date to find suitable materials exhibiting the broad range of BUA values observed in the calcaneus, from 20 dB MHz^{-1} to 120 dB MHz^{-1} .

As with most materials, the propagation of ultrasound through cancellous bone mimics the roll-off response of a low-pass electronic filter, the amplitude reducing exponentially with increasing frequency. The BUA measurement may therefore be simulated by an electronic low-pass filter. A multi-stage BUA calibration phantom has been developed for commercial ultrasound systems incorporating a back-to-back transducer arrangement which physically replaces the calcaneus. The electronic bone phantom has been shown to have high intra- and inter-phantom accuracy and precision.

3. QUALITY ASSURANCE

Comparison of commercial system performance to date has concentrated on precision, defined as the Co-efficient of Variation (CV%), given as (Standard Deviation/Mean)x100 for a subject. CV% is insensitive to variation in population dynamic range for a particular measurement parameter and also to algorithm modification.

CALIBRATION AND QUALITY ASSURANCE PROCEDURES

The Standard Deviation of Z-Score (ZSD) has recently been proposed as a unified precision parameter. The value of ZSD has been compared for ultrasound velocity and BUA measurements in the calcaneus. The precision, defined by CV%, for velocity is an order of magnitude superior to BUA, which reduces to a more representative factor of two when population dynamic range is incorporated via ZSD. Modification of the BUA algorithm within a particular commercial system may significantly improve the apparent precision, defined by CV%, which is unified by ZSD.