Application of Dual Frequency Ultrasound Method in Through Transmission Measurements

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Introduction

Soft tissue layers overlying bones, with unknown thickness, can produce significant errors to bone quantitative ultrasound measurements [1,2]. In this study dual frequency ultrasound (DFUS) technique [3,4], developed originally for pulse-echo measurements, is applied and evaluated in a configuration typical to clinical through-transmission measurement.

Material and Methods

In this study, a modification of DFUS algorithm is presented for determination of soft tissue composition, *i.e.* amount of lean and fat tissue, and correction of typical clinical parameters such as broadband ultrasound attenuation (BUA) and speed of sound (SOS) in through transmission geometry. Ultrasound soft tissue phantoms mimicking lean and fat tissues were tested in five different configurations by varying the composition (0-100% of fat). Different configurations were built using 10mm of fat or lean and 30mm of fat or lean, and total thickness of soft tissue constructs varied from 20mm to 40mm. Second, bone phantoms were measured in three configurations: 1) only bone phantom, 2) 10mm of fat and 30mm of muscle and bone phantom and 3) 30mm of fat and 10mm of muscle and bone phantom. Average attenuation (AA) and broadband ultrasound attenuation (BUA) were calculated.

Results

Using through-transmission measurements at 0.5 MHz center frequency the thickness of soft tissue layers could be determined using DFUS technique (low and high frequency band 0.4-0.45 and 0.55-0.6 MHz, respectively). In measurements of soft tissue layers, average absolute error of fat/muscle layer thickness was 2.2mm (standard deviation (SD = 1.3mm). Placement of the soft tissue phantoms on top of the bone phantoms produced an average error of 21% (1.04 dB/cm) and 17% (8.31 dB/MHz) to AA and BUA values, respectively. By using the soft tissue thicknesses obtained with DFUS method, the errors were decreased to 5%(0.27 dB/cm) and 1% (0.55 dB/MHz) in AA and BUA, respectively.

Discussion

The results suggest that DFUS method may be used in through-transmission measurements for assessment of soft tissue content over/underlying the bone. The errors in quantitative ultrasound parameters (AA and BUA) were significantly reduced when DFUS method was applied. Therefore, the method may enhance the reliability of transmission measurements. At present, the findings of this study are under further validation with bone specimens. Finally, in vivo measurements are needed to gain better understanding on the clinical potential of the method.

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