Improving accuracy of shear wave elastography with optimized-refraction compensation method

Jun Yasuda[1], [1]Hitachi ltd., Tokyo, Japan

Background, Motivation and Objective

In shear wave elastography (SWE), focus deformation of pushing ultrasound beam caused by tissue structure distorts shear wave and it reduces accuracy of SWE. Refraction at a boundary between subcutaneous fat and muscle is one of main reasons for such focus deformation. The objective of this study is to improve accuracy of SWE by correcting such focus deformation.

Statement of Contribution/Methods

We proposed optimized refraction-compensation method to achieve the objective. In this method, firstly, boundary shape between subcutaneous fat and muscle was detected by B-mode images. Next, ultrasound paths from ultrasound probe elements to multiple points in ideal focal region are calculated based on Snell's law. Then, optimized delay time and amplitude of each probe element which maximizes radiation force in ideal focus region are calculated with considering length of the paths, sound of speed, and attenuation of each tissue. Improvement effect of the proposed method was evaluated by numerical simulations. Three biological tissue models mimicking subcutaneous fat and muscle layers were created. Average thicknesses of fat layers were 10, 20 and 30 mm. A 64-ch linear probe model was also modeled and pushing ultrasound on the condition of non-compensated and refraction-compensated were transmitted from the probe at a frequency of 3 MHz. Then, acoustic pressure distribution around focus region, waveform of shear wave and measurement error of shear wave velocity were evaluated.

Results/Discussion

Figure A shows acoustic pressure distributions around focus region in the case of fat thickness of 30 mm. In non-compensated case, focus region was dramatically deformed. On the other hand, in compensated case, it was corrected. Figure B shows shear wave on lateral-time plane in the case of fat thickness of 30 mm. White dotted lines indicates peak times of shear wave. In non-compensated case, shear wave was distorted and the peak time was also distorted. On the other hand, in compensated case, they were corrected. Figure C shows measurement error of shear wave velocity in each fat thickness. Errors of compensated cases became much lower than non-compensated cases. From these results, accuracy improvement of SWE with optimized-refraction compensation method was demonstrated.

Figure A

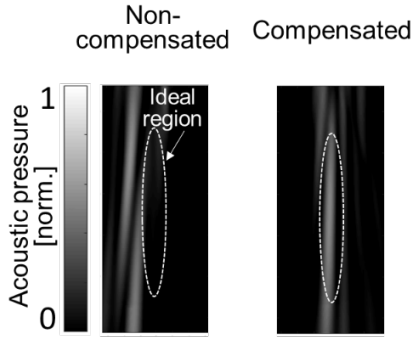

Figure B

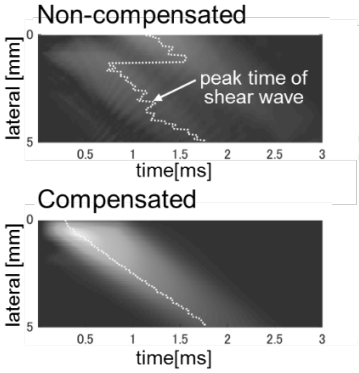

Figure C