Two Transducer Approach for Simultaneous High-Sensitivity and High-Resolution Shear Wave Elasticity Imaging

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Background, Motivation and Objective

Shear wave elasticity imaging (SWEI) is usually implemented using a single array transducer both to generate shear waves and to track their displacements. To induce shear waves at distant ranges, lower frequency deep-penetrating ultrasound is desired. Conversely, to achieve higher spatial resolution, higher frequency ultrasound is preferred. However, ultrasound array transducers are typically band-limited; thus, adequate shear wave generation and high-resolution imaging cannot be simultaneously achieved. To address this challenge, we are introducing a dual-transducer SWEI approach.

Statement of Contribution/Methods

SWEI was performed on a 4% gelatin phantom containing a cylindrical inclusion with an 8% gelatin concentration. The phantom was imaged using a Verasonics Vantage ultrasound system. In the dual-transducer SWEI approach, shear waves were generated using a 5 MHz single-element transducer (Olympus, Inc.) and tracked using L22-14vLF operating at 15 MHz center frequency. These measurements were compared with those obtained using the single-transducer SWEI approach, in which shear waves were both generated and tracked using either an L7-4 at operating at 5 MHz (push/track) or an L22-14vLF operating at 15 MHz.

Results/Discussion

The B-scan images of the phantom with inclusion (at ~17 mm depth) obtained using L7-4 (5 MHz, Fig. 1A) and L22-14vLF (15 MHz, Fig 1B) transducers clearly show the difference in spatial resolution. The shear waves obtained using low-frequency L7-4 array transducer (Fig. 1C) were able to reach the inclusion, while high-frequency L22-14vLF array transducer could only create low amplitude shear waves in the inclusion (Fig. 1D). In contrast, our dual-transducer approach produced high amplitude shear waves at depth (Fig. 1E). The comparison of shear wave images in Fig. 1 reveals that (1) low-frequency array transducer can generate shear waves of high-intensity at deeper regions, but spatial resolution is low; (2) high-frequency array transducer can achieve high-resolution imaging but shear waves are limited to shallow depth. However, as evident from Fig. 1E, the dual transducer approach can achieve both high-resolution imaging and high penetration depth. Our results suggest that the developed approach may enable biomedical applications where high-resolution shear wave tracking is required.

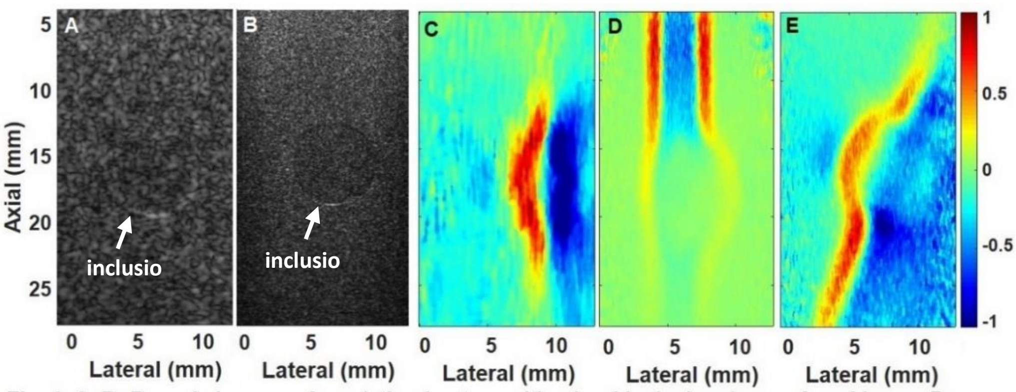

Fig. 1. A, B: B-mode images of a gelatin phantom with a hard inclusion. Image A and image B were acquired using L7-4 at 5 MHz and L22-14vLF at 15 MHz, respectively. C, D: Shear wave images obtained using single-transducer approach where shear wave excitation and tracking were executed at the same frequency. Image C and image D were acquired using L7-4 at 5 MHz and L22-14vLF at 15 MHz, respectively. E: Shear wave image obtained using dual-transducer approach: 5 MHz single-element transducer used for shear wave excitation and L22-14vLF (15 MHz) used for tracking.