High-Frequency Ultrasound Shear Elastography: A New Approach for Evaluating the Performance of Human Hand Tendon During Rehabilitation

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Background, Motivation and Objective

Tendon stiffness plays an important role in tendon healing process. Many studies have reported that the tendon stiffness during recovery is highly related to the functional outcomes of repaired tendons. However, hand tendon is a superficial tissue with a thickness around 1-2 mm, which makes the commercial ultrasound elastography is difficult to measure its stiffness. Therefore, in the present study, a high-frequency ultrasound shear elastography (HFUSE) was developed for measuring the shear wave velocity (SWV) of hand tendons.

Statement of Contribution/Methods

Figure 1 (a) shows the schematic diagram of HFUSE. An external vibrator (Mini-shaker type 4810, Bruel & Kjaer, Nærum, Denmark) was coaxially mounted on a high-frequency ultrasound transducer (Vevo MS550D, FujiFilm, VisualSonics, Toronto, ON, Canada) to continuously create longitudinal shear waves in hand tendon. Single plane wave imaging was transmitting into hand tendon at a frame rate of 8 kHz to track the longitudinal shear wave. The signal processing procedure illustrates in Fig. 1(b). The particle velocity data was calculated by using the 1-D autocorrelation. An empirical mode decomposition was applied to the particle velocity data to suppress the vibration artifacts because the HFUSE was designed for continuous vibration. The phase at different depths was estimated through a spectral analysis. Finally, a shear wave velocity map of hand tendon was reconstructed by using a two-step linear regression method.

Results/Discussion

A typical 40 MHz B-mode image of human hand tendon is shown in Fig. 1(c). The skin and hand tendon were recognized clearly in the figure. The color-coded SWV maps from three patients with different rehabilitation periods (3, 9, and 11 months) were overlaid on the B-mode images, as shown in Fig. 1(d). According to the results from three patients, the mean SWV of healthy tendon were 0.54 m/s, 0.54 m/s, and 0.53 m/s. The mean SWV of injured tendon after rehabilitation were 1.46 m/s (3 months), 0.91 m/s (9 months), 0.62 m/s (11 months). The SWV of hand tendon during tendon healing is highly related to the functional outcome of hand tendon. All the results demonstrated the feasibility for HFUSE to measure the SWV of hand tendons, and the potential of being a tool for evaluating the performance of hand tendons after rehabilitation.

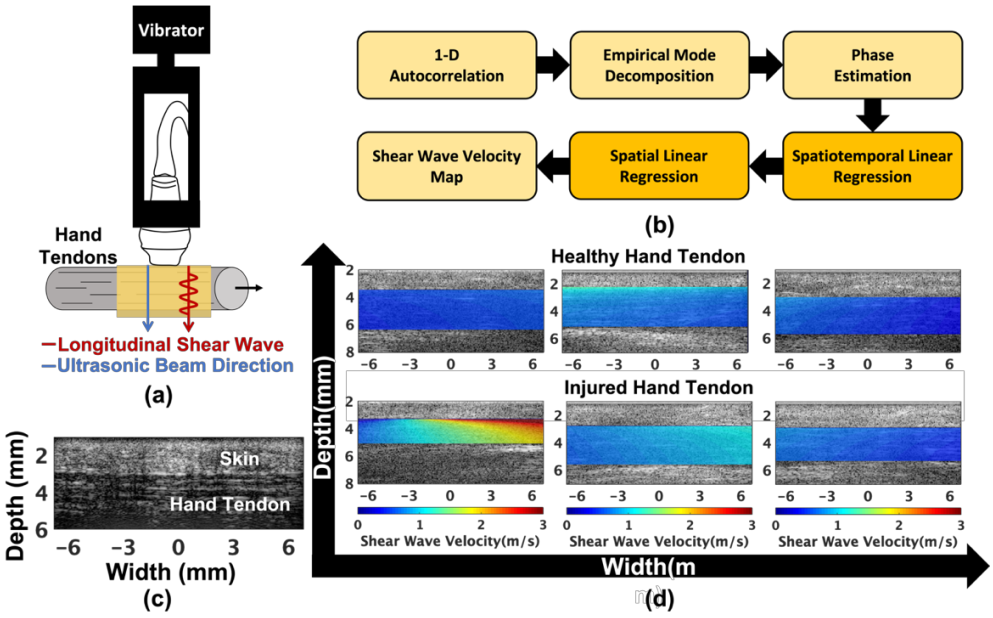

Figure 1