4-D Lamb Wave Imaging of Porcine Cornea using 40 MHz High-Frequency Ultrasound

Chien-Chang Weng, Pei-Yu Chen, Chih-Chung Huang[1]
Department of Biomedical Engineering, National Cheng Kung University, Taiwan.

Background, Motivation and Objective

Measurement of the elasticity distribution of cornea is important because the corneal elasticity is usually influenced by the corneal pathologies and surgical treatments, especially for the early corneal sclerosis. However, the thickness of cornea is typically around 1 to 2 mm, the elastic wave propagating in cornea is defined as Lamb wave. A 4-D Lamb wave propagation image can provide researchers to understand the wave physics in cornea, however, it's only available in optical approaches due to the high resolution. Therefore, this study presents a new high-frequency ultrasound (>30 MHz) Lamb wave imaging (HFLWI) technique to visualize the Lamb wave for normal and sclerosed corneas in 4D.

Statement of Contribution/Methods

Fig. 1(a) shows the schematic of HFLWI. An external vibrator (Mini-shaker type 4810, Bruel & Kjaer, Nærum, Denmark) with a small piston was placed on the side of porcine eye ball to create transverse Lamb wave inside the corneal sample. The diameter of the piston is 1 mm. A 40 MHz high-frequency ultrasound transducer (Vevo MS550D) with a high-frequency ultrafast ultrasound imaging system (Vantage 256) was used to acquire the ultrasound backscattering data. Single plane wave imaging at a frame rate of 8 kHz was used to track the Lamb wave. A 4-D HFLWI propagation images were reconstructed by a 1-D auto-correlation algorithm via a mechanical scanning of array transducer across the eye ball. Finally, a 2D-FFT algorithm was used to calculate the phase velocity for quantitative comparison.

Results/Discussion

Fig 1(b) shows the HFLWI images of normal and sclerosed corneas, respectively. The Lamb wave can be clearly observed in 2D & 3D images. The Lamb wave propagates faster in the sclerosed region than in the normal region. The mean phase velocities of normal and sclerosed corneas were 2.27 m/s and 3.72 m/s, respectively. All the results demonstrated the potential of 40-MHz HFLWI as a tool for visualizing the Lamb wave propagation in cornea and helps researchers to understand the wave physics in cornea.

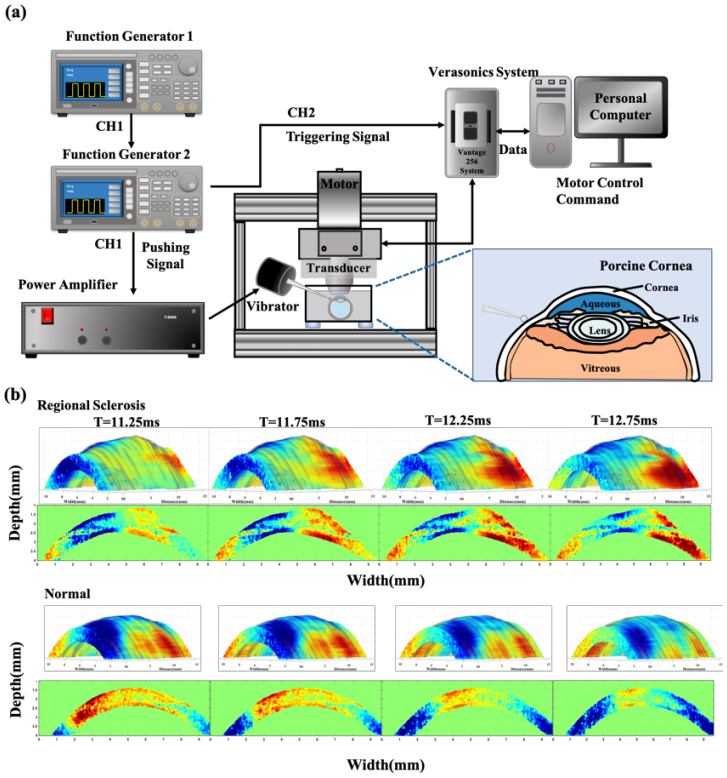

Fig 1