USC Roski Eye Institute
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Research the Anisotropy Property in Equator Sclera Using High Frequency Ultrasonic Elastography

USC Ginsburg Institute for Biomedical Therapeutics

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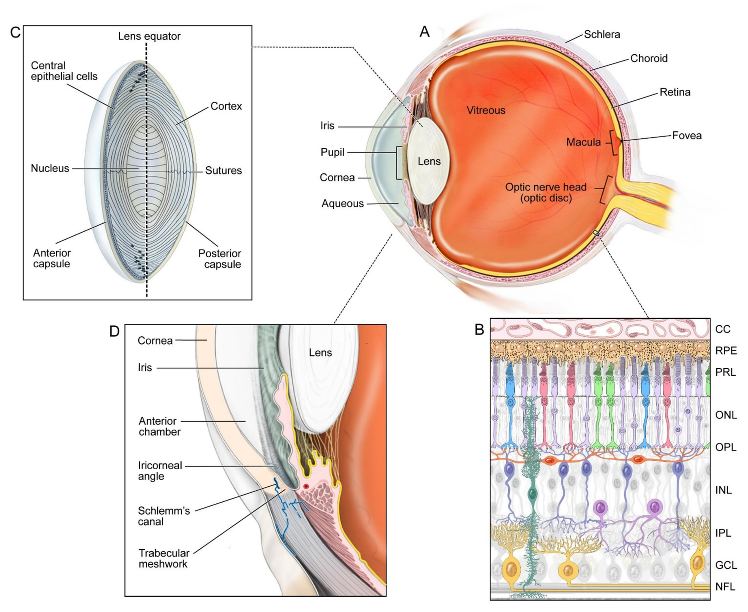
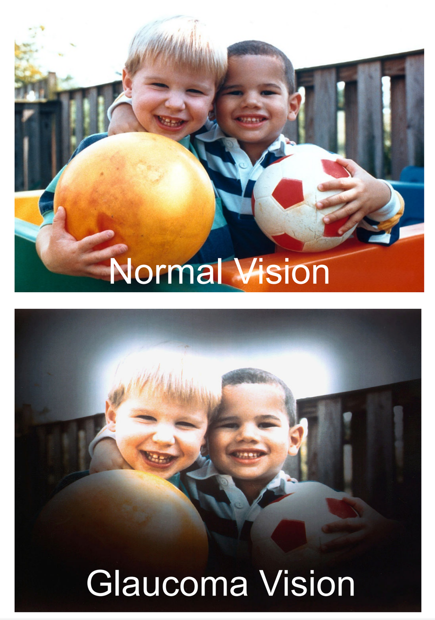
I. Introduction

- Glaucoma is one of the leading causes of blindness about 2 million people are affected in the US.
- Elevated IOP is the most risking factor to cause the biomechanics alteration in optic nerve head, as well as other tissues in the eye.
- The equator sclera plays a pivotal role in vision as it provides stable mechanical support to the optic nerve and retina under dynamic force loading condition.
- High frequency ultrasonic elastography can investigate the anisotropy property experimentally in the superior, temporal, nasal and inferior locations.





Advantages:

1. 18 MHz linear array enables high spatial resolution.
2. Deep imaging depth compared with optical coherence tomography (OCT)

II. Methods

Due to the strict Food and Drug Administration regulation of the ultrasound acoustic power for eye application, a piezoelectric shaker was used to induce tissue motion instead of acoustic radiation force. A mechanical shaker (mini-shaker type 4810; Bruel & Kjaer) was positioned at the equator sclera to initiate the elastic wave propagation. An ultrasonic array (L22-14v; Verasonics Inc.) was positioned above the equator sclera and its beam was aligned to be parallel with the shaker.

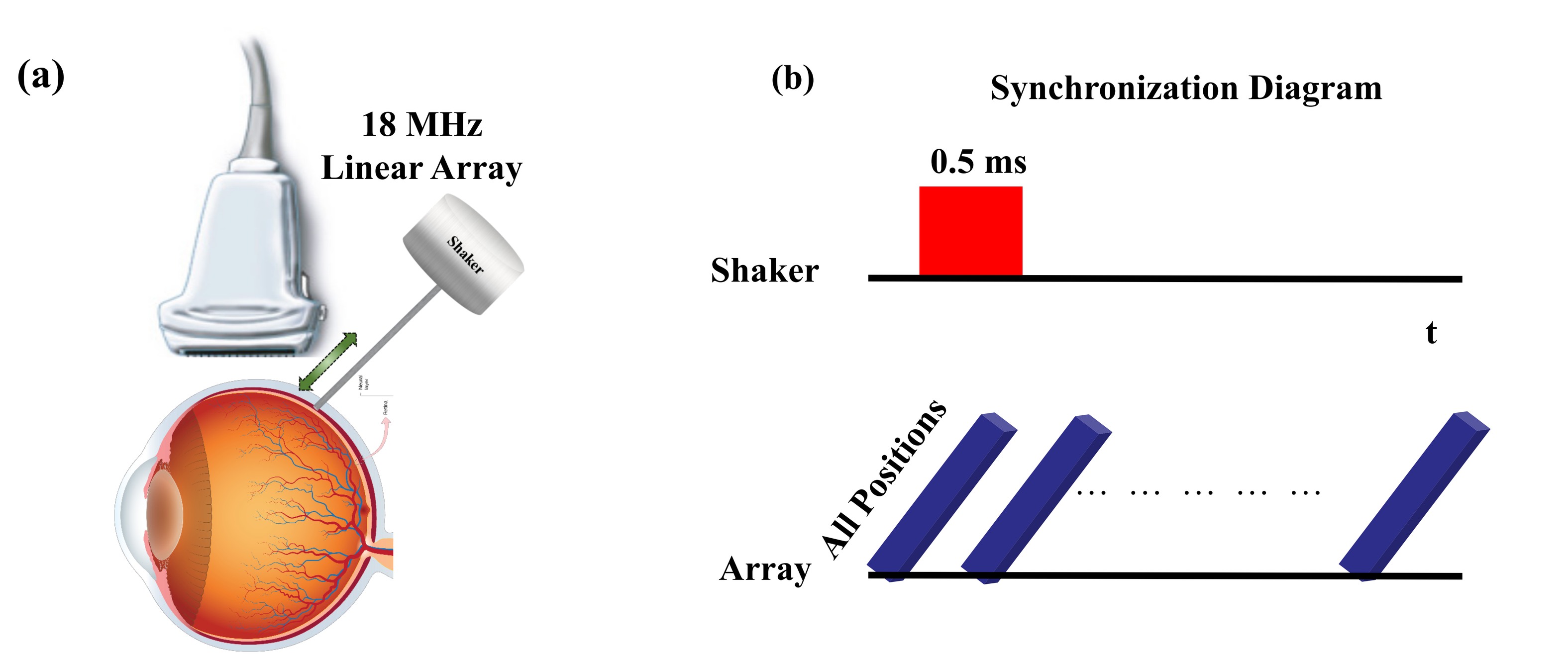


Fig 1. (a) The diagram of the high frequency ultrasonic elastography configuration. This array has the center frequency of 18 MHz and the bandwidth of 67%. The diameter of the shaker tip is around 2 mm and positioned at the sclera, the axial displacement it induces is 1 ~ 10 μm. (b) The diagram of the system synchronization. The shaker vibrates for 0.5 ms and the array acquires the M-mode raw data at every lateral positions in a 7 KHz pulse repetition frequency. The axial displacement is then calculated by using cross-correlation algorithm with acquired M-mode raw data.

III. Results

(a) (b) (c) (d)

B-Mode Imaging and its corresponding Spatial-Temporal Map in Different IOP at Superior Position

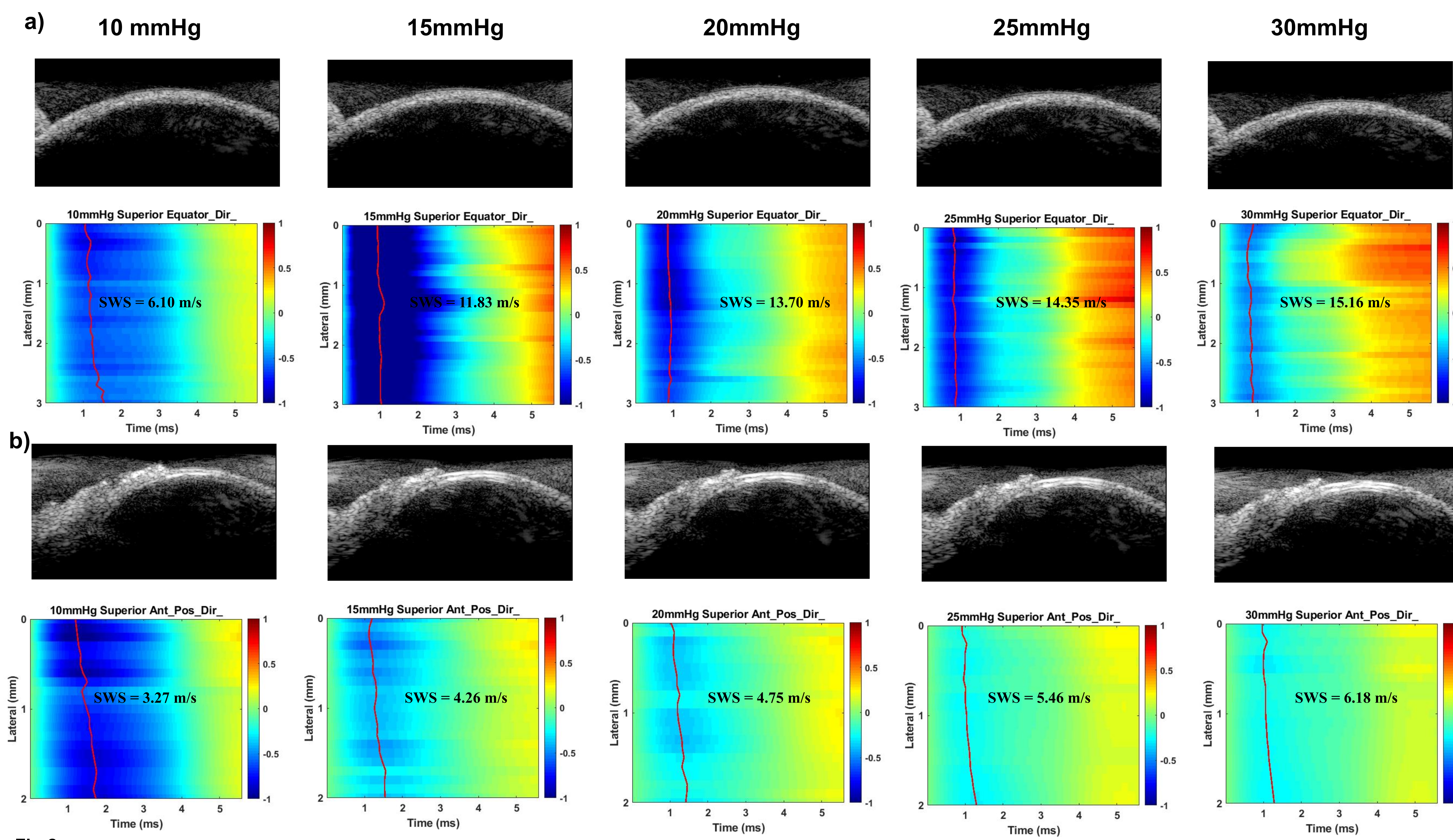


Fig 2. B-Mode Imaging and its corresponding Spatial-Temporal Map in Different IOP at Superior Position. a) Along with the equatorial direction. b) Along with the anterior to posterior direction. The slope of the red line represents the shear wave speed. The shear wave speed of from 10 mmHg to 30mmHg in equatorial direction is 6.10 m/s, 11.83 m/s, 13.70 m/s, 14.35 m/s and 15.16 m/s respectively, in the other direction, it is 3.27 m/s, 4.26 m/s, 4.75 m/s, 5.46 m/s and 6.18 m/s respectively.

IV. Conclusion and Future Plan

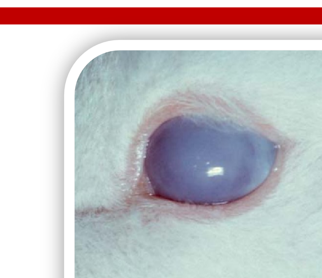
Conclusion

- In this study, the anisotropy property of equator sclera has been investigated using high frequency ultrasonic elastography, it tends to be stiffer in the equatorial direction.
- Our system has the potential to explore how the progression of the glaucoma affects the biomechanical properties of the equator sclera and vice versa.

Future Plan

1. High frequency linear array is used in this study, and 2D cross-sectional imaging is provided. For 3D imaging, a motor will be finally equipped.
2. Cadaveric porcine eyes were used in this study, in the future we will conduct *in vivo* study by using normal rabbits and hyper-intensive glaucoma model rabbits to further investigate how the progression of glaucoma affects this anisotropy property.

Mechanical Motor



Glaucoma Rabbit Model
D. Williams EJCAP, 17 (3), pp. 242-252

V. Acknowledge and Support

This work was supported by the NIH NEI grant R01EY028662, R01EY026091, R01EY030126, R01CA211602 and NIH P30EY029220, and an Unrestricted Departmental Grant from Research to Prevent Blindness, New York, NY 10017.

Research to Prevent Blindness