Healthcare Innovations
How practice has changed

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Static compression optical coherence elastography to measure mechanical properties of soft contact lenses

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Purpose

- Understanding the mechanical properties of the eye is important since changes in mechanical properties are known to occur in a range of eye diseases and following surgical procedures. Currently, there is no clinical method for comprehensively evaluating the eye's mechanical properties.
- Optical coherence tomography (OCT) imaging has revolutionized eye research and clinical care.
- Elastography is a method of determining the mechanical properties of a material through deforming with a known force and measuring its displacement through sequential images. The principles of elastography can be applied using OCT imaging to create optical coherence elastography (OCE) (Fig 1).
- OCE methods typically require sophisticated modifications to OCT instruments. This study aims to create a method to measure the mechanical properties of a material using a clinical OCT instrument and without the use of complex electronics to measure applied forces, such that it may be translated into a clinical setting for in vivo measures in the future.

Methods

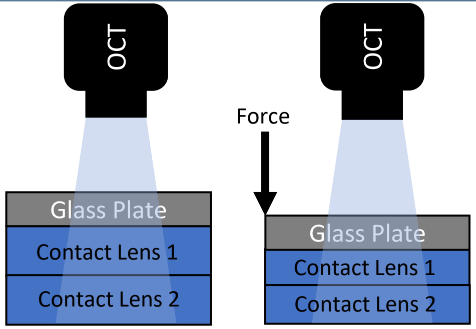

Fig 1. Elastography principle. Pre-loaded on the left and compressed on the right.

- Several soft contact lens materials with well defined biomechanics were used as ~~a~~ phantoms to mimic ocular tissue.
- Two contact lenses (one of known properties acting as a stress sensor and the other under investigation) were placed on top of one another and were compressed by a glass plate.
- Sequential high resolution cross-sectional images were captured with OCT during pre-load (baseline) and under compressive load (~10% strain).

$$E = {}^{\sigma}/_{\varepsilon} \quad \text{Eq (1)}, \qquad \sigma_1 = \sigma_2 \quad \text{Eq (2)}$$

- The thickness of the contact lenses was derived through automatic boundary segmentation to measure the strain during compression (Fig 2).
- The stress (σ) of the top contact lens of known properties (stress sensor) under compression was found by rearranging Eq 1.
- This stress was then mapped onto the second lens (bottom), assuming Eq 2. Its Young's modulus (E) was then found using Eq 1.

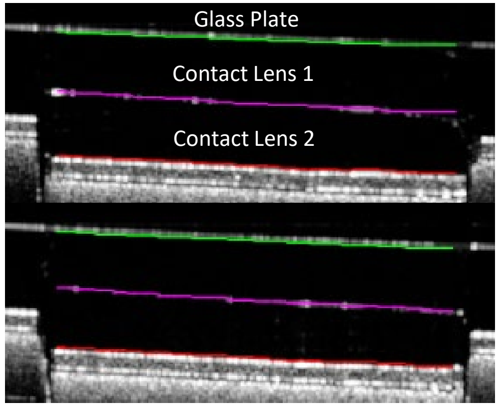

Fig 2. Segmented OCT images. Pre-loaded (top). Compressed (bottom).

Results

Table 1. Young's Modulus of Five Contact Lens Materials Tested (MPa)

Stress sensor material	Tested material	Nominal	Mean ± STD	Percentage Difference (%)
Omafilcon A	Omafilcon A	0.40	0.426 ± 0.027	6.238
Senofilcon A	Senofilcon A	0.73	0.729 ± 0.013	0.077
Lotrafilcon B	Lotrafilcon B	1.20	1.207 ± 0.029	0.777
Omafilcon A	Senofilcon A	0.73	0.724 ± 0.036	0.809
Senofilcon A	Lotrafilcon B	1.20	1.183 ± 0.192	2.400

- All measured values showed close agreement with the nominal values (Table 1).
- There was minimal variation in repeated measurements, with the standard deviation less than 0.2 MPa for all contact lenses.

Conclusions

- Results demonstrate that a compression based OCE method can accurately measure the mechanical properties of a material without the use of a force sensor.
- This proof of principle, provides the foundation for future testing using ocular tissue.

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