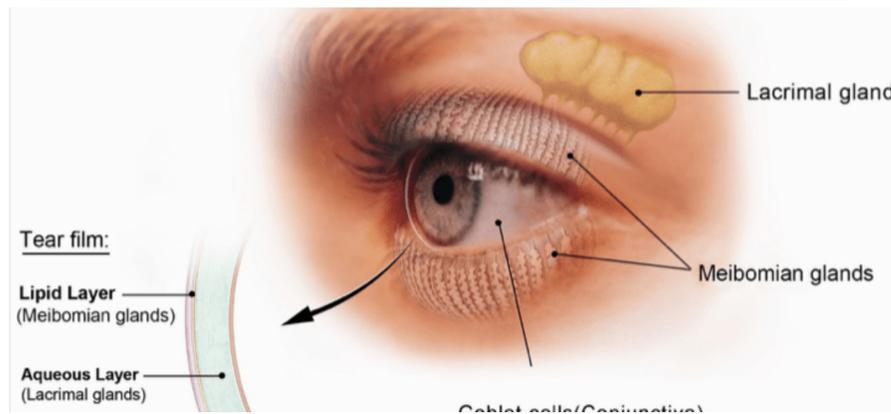


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I. Purpose

- **Dry eye disease (DED)** is one of the most common ophthalmic disease with a high incidence of 7% - 33% of population.
- **Meibomian gland dysfunction (MGD)** accounts for more than 70% of DED cases.
- Current treatment options to MGD are limited.



Our Goal:

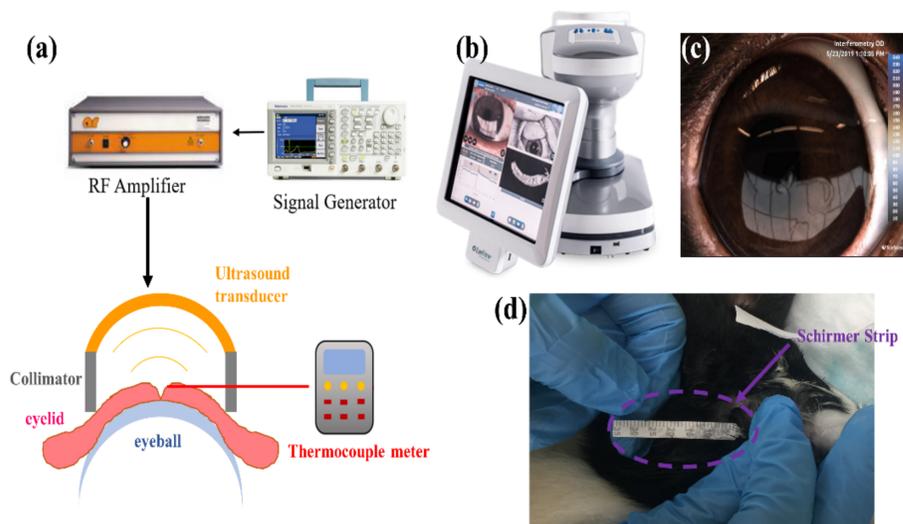
Focused ultrasound stimulation on MGD to treat the related dry eye disease (DED).

Advantages:

- Safety and Noninvasiveness
- Efficient and long-term effects
- No side effects

II. Methods

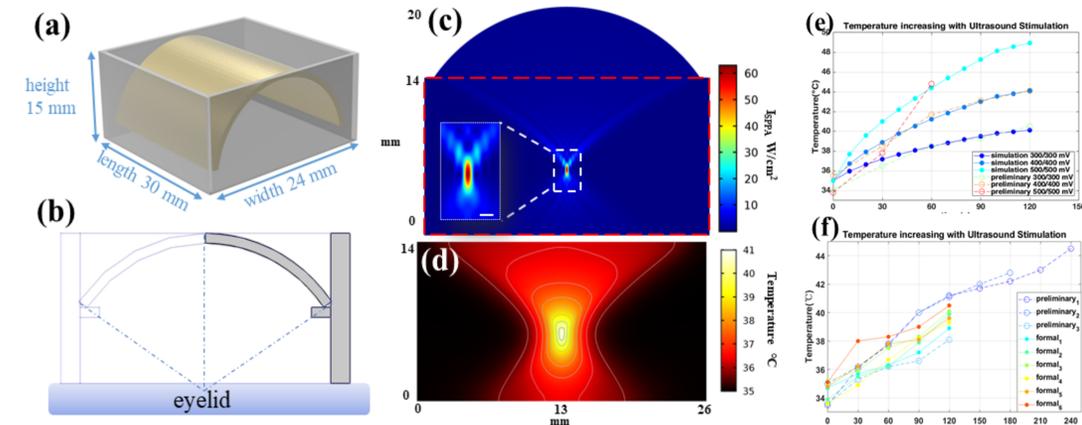
Ultrasound is a safe technology that has been widely used for medical applications. Ultrasound stimulation is emerging as a non-invasive approach to treatment. In this study, a novel focused ultrasound treatment modality was designed and applied to stimulate meibomian gland secretions in healthy rabbits. As a non-invasive treatment modality, ultrasound has both a heating and stimulating effect to improve meibomian gland secretions and MGD.



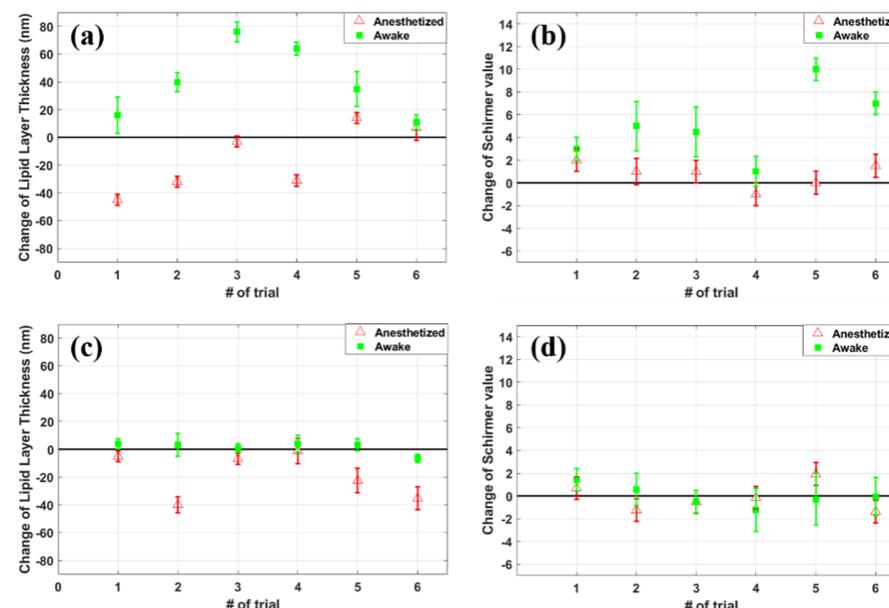
III. Results

(1) Ultrasound transducer and its ultrasound field distribution

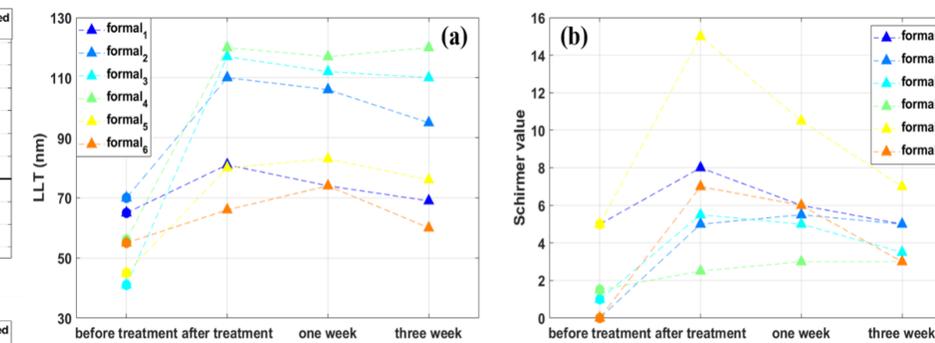
- Specific-designed linear focused ultrasound transducer to match the shape of meibomian gland. (a&b)
- Center frequency 3.3 MHz, with a confined focal area (0.4 mm by 1 mm). (c&d)
- Ultrasound intensity: $I_{spta} = 6.2 \text{ W/cm}^2$.
- Mechanical Index = $0.75 < 1.9$ (FDA requirement).
- Ultrasound stimulation can increase the temperature of local tissue gradually and controllably. (e&f)



(2) Changes in Lipid layer thickness and tear production



(3) Long-term effect after ultrasound stimulation



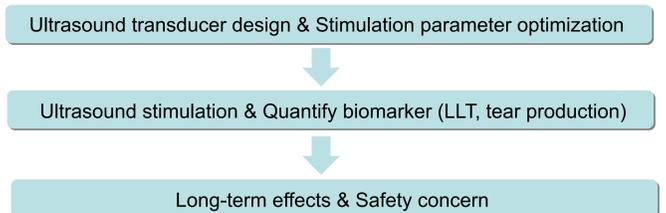
- Ultrasound stimulation on the meibomian gland increased both the lipid layer thickness (LLT) and tear production.
- LLT was increased from $55.33 \pm 11.15 \text{ nm}$ to $95.67 \pm 22.77 \text{ nm}$.
- Tear production was increased from 2.0 ± 2.3 to 7.2 ± 4.3 .
- The effect of both LLT and tear production can last more than three weeks.

IV. Discussion and Conclusion

- Our results suggest that the ultrasound stimulation on meibomian glands can improve both tear production and lipid secretion.
- The positive effect can last at least three weeks.
- No adverse effect was caused by the determined-safe ultrasound treatment settings.
- With advantages such as safety, convenience, and cost-effectiveness, ultrasound treatment has the potential to become a valued option for patients to treat evaporative DED caused by MGD.

The future developments of this technique:

- Investigate the effectiveness of the proposed method on different animal strains with dry eye disease model.
- Design and build ultrasound array for automatically scanning stimulation strategy, to get a homogenous stimulation effect.



V. Acknowledge and Support

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