MEDICAL UNIVERSITY OF VIENNA

Abstract #3543230

Determination of the protective properties of Ophthalmic Viscosurgical Devices through an automatic segmentation pipeline of the anterior segment in porcine eyes using OCT

Philipp Matten, MS[1], Melanie Wuest, BS[2,1], Oliver Findl, MD[3], Rainer A. Leitgeb, PhD[1] and Wolfgang Drexler, PhD[1]

[1] Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria; [2] Aalen University of Applied Sciences, Aalen, Germany; [3] Department of Ophthalmology, Hanusch Hospital Vienna, Vienna, Austria

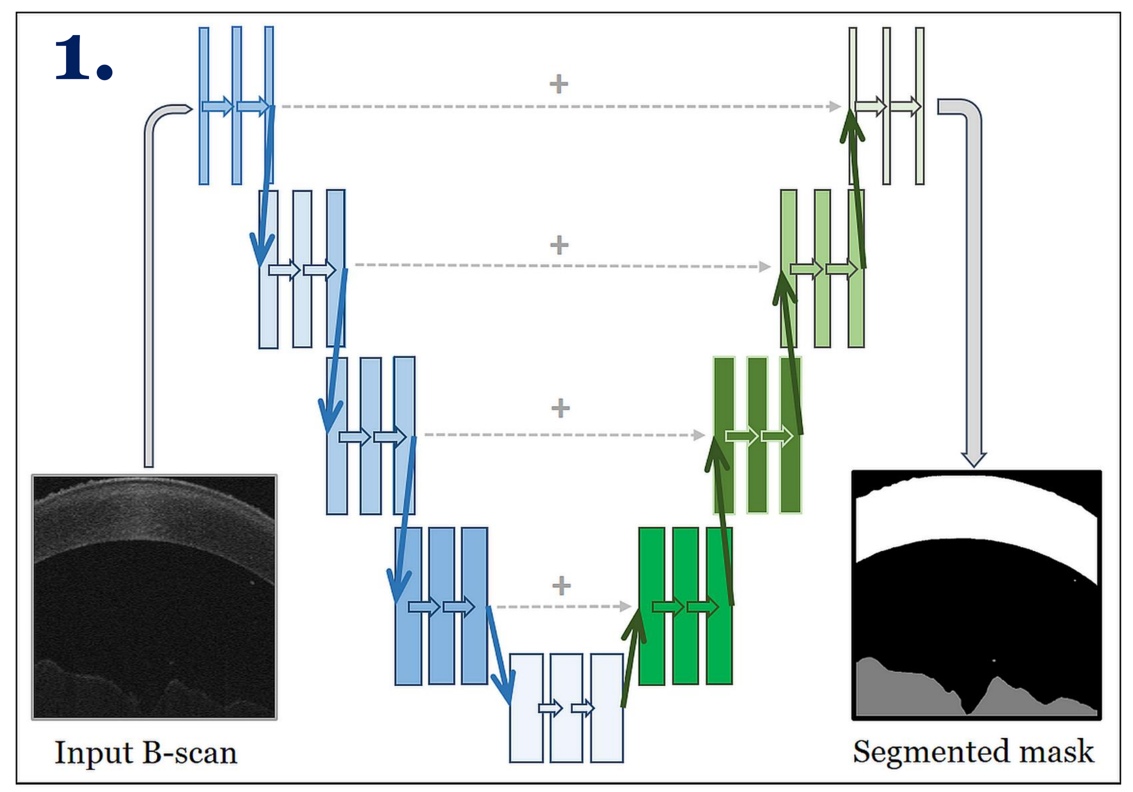
Purpose

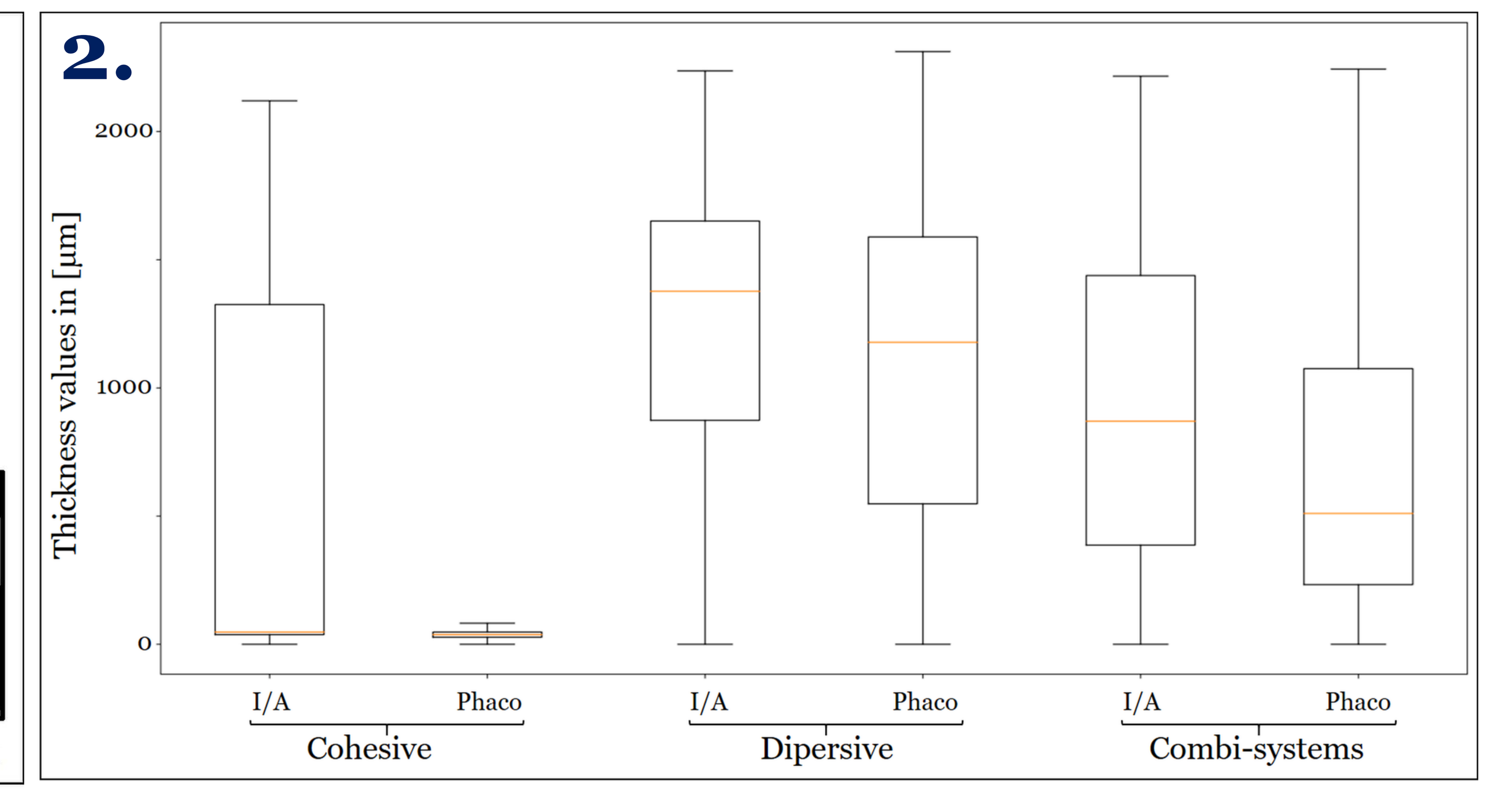
- During cataract surgery the lens gets destroyed with ultrasound, using a probe (phaco tip)
    - Fragments become projectiles that cause irreversible damage to the corneal endothelium
- To coat the endothelium with a protection layer, Ophthalmic Viscosurgical Devices (OVDs) are injected into the anterior chamber.
- The protective properties and thickness of OVDs have previously been the subject of investigation, using fluorescein and a Scheimpflug camera [1, 2].
- Protective properties are still poorly understood.
- We present a method to quantitatively evaluate the distribution of OVDs, using Optical Coherence Tomography (OCT) and a Convolutional Neural Network (CNN) (Fig. 1).

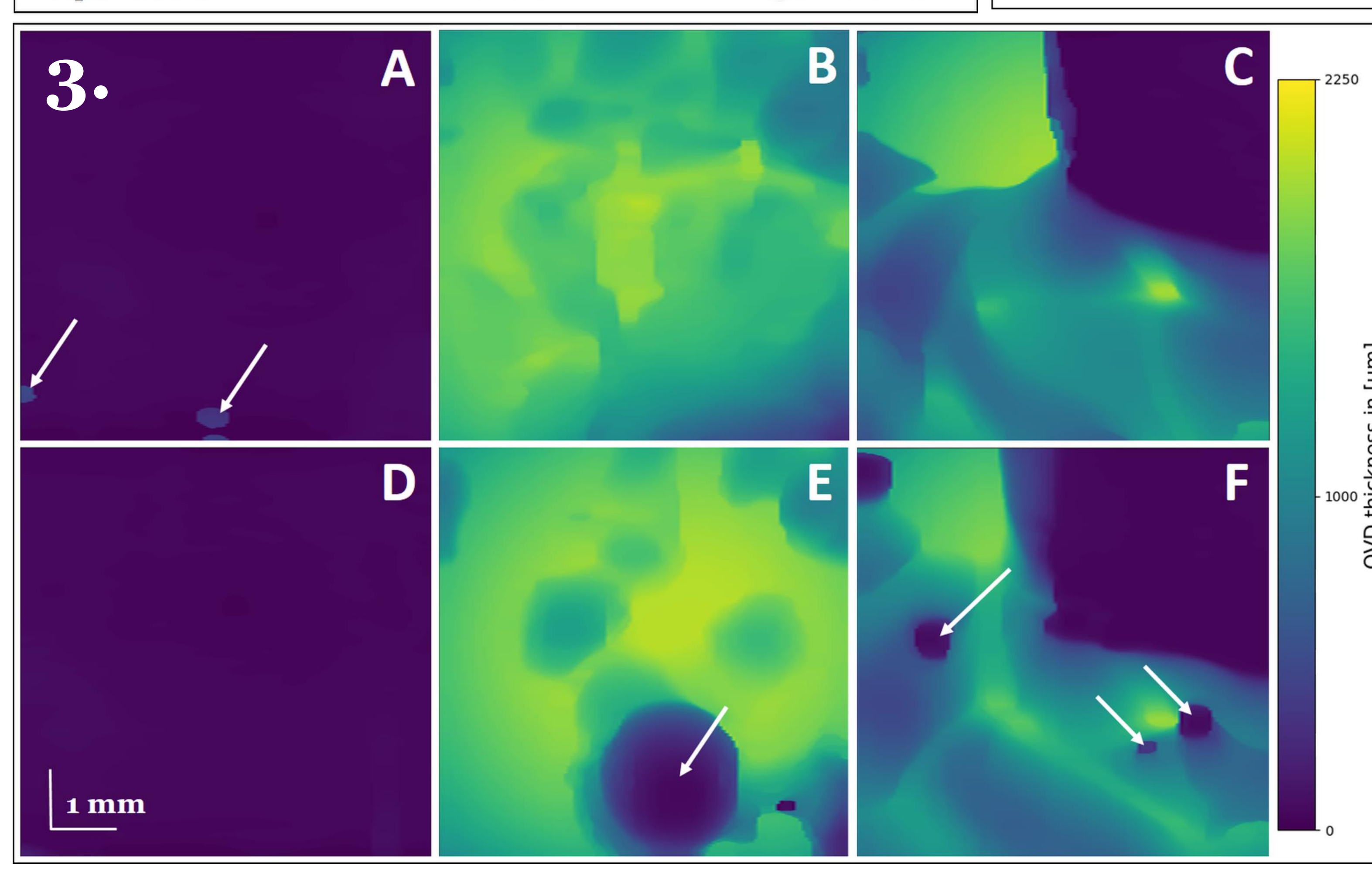
Methods

- Simulated cataract surgery (irrigation & aspiration (I/A) and phacoemulsification (phaco)).
- We used BSS-milk-solution (100:1) to generate contrast using OCT (Fig. 4 (iii)).
- We imaged 10 different OVDs each 10 times
    - Twice: each after I/A and after phaco
    - Scan size 2.9 (Z) x 6 (X) x 6 (Y) mm³.
    - Sampled @ 1024 x 512 x 128 pixels.
    - with ZEISS LUMERA® 700 with ZEISS RESCAN® 700 as OCT modality.
- Segmentation pipeline consists of
    - Manual segmentation path - segmented ~3000 B-scans manually for training.
    - Automatic segmentation path (based on Unet [3]) - automatically segmented 25.600 B-scans.
- Trained CNN to segment 3 semantic categories
    - the cornea (Fig. 4 (i) - white).
    - OVD/Background (Fig. 4 (ii) - black).
    - BSS-milk-solution (Fig. 4 (iii)- gray).

Contact: philipp.matten@meduniwien.ac.at







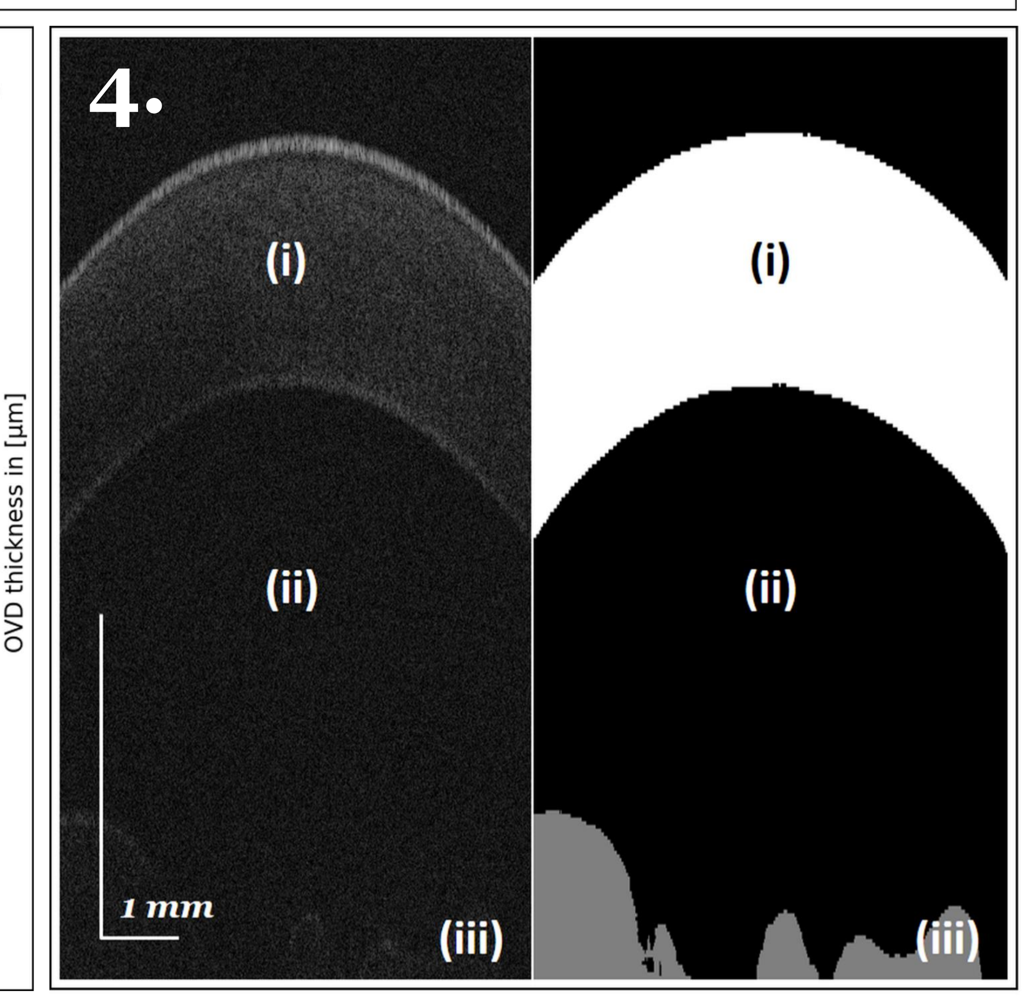


Figure 1. The architecture of the CNN was trained to perform semantic segmentation of the B-Scans. The architecture was based on UNet architecture [3]; **Figure 2.** Boxplots of the combined OVD groups: dispersive and cohesive and combi-systems. The left-hand-side plots show the combined values after I/A and the right-hand-side plots after phaco for each OVD group; **Figure 3.** Example thickness/heat maps of different OVDs: PROVISC® (Alcon) A&D, AMVISC® PLUS (Bausch + Lomb) B&E and DUOVISC® (Alcon) C&F. Upper row: after I/A and lower row: after phaco. The arrows indicate bubble formation (center and right column) and grafts of OVDs at the endothelium (left column); **Figure 4.** Side-by-side view of the original B-scan (left) and the false-color overlay segmented mask (right). (i) Cornea, (ii) OVD, and (iii) milk-BSS-solution.

Results

- We quantitatively determined the protective properties of OVDs via thickness maps (Fig. 3 A-F).
- Maps revealed huge fluctuations of the individual measurements (Fig. 2 and 3 A-F).
- Median thickness values ranged from 39 ± 599 µm (PROVISC®) up to 1437 ± 489 µm (Healon EndoCoat).
- Cohesive OVDs have the thinnest layer values, followed by combi-systems. Dispersive OVDs had the highest group median thickness value (Fig. 2).

Conclusion

- We measured for the first time the thickness of the OVD over a large FOV of 6 x 6 mm².
- We've evaluated the protective properties of 10 different OVDs from which we acquired a large database of 200 OCT volumes measurements from 100 porcine eyes.
- Understanding layer formation and persistence over especially such a large FOV are essential steps for the comprehension of the protective properties of OVDs and potentially for
    - surgeons to get the confirmation that protection was ensured during surgery.
    - manufacturers of OVDs to improve the properties of their products.
- Our pipeline can be expanded to segment 3D data which would increase the spatial accuracy of the segmentation.

References

[1] Yoshino M, Bissen-Miyajima H, Ohki S (2009). Jpn J Ophthalmol 53(1):62–64. doi:10.1007/s10384-008-0601-3

[2] Mori H, Yamada H, Toyama K, Takahashi K (2018). Heliyon 4(9):e00822. doi:10.1016/j.heliyon.2018.e00822

[3] O. Ronneberger et al., 2016, https://doi.org/10.1007/978-3-319-24574-4_28

Disclosures

P. Matten (F), M. Wuest (C), O. Findl (C), R. A. Leitgeb (C,F), W. Drexler (C,F)