Determination of Thickness Profiles of Toric SCLs and New Relevant SHCLs Using *Scheimpflug* Technology

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Introduction:

Oxygen transmissibility (Dk/t) is one of the most important influencing values on the adjustment of soft contact lenses (SCL) to keep eyes healthy. As oxygen transmissibility depends on lens thickness, it can be measured by dividing oxygen permeability (Dk) by lens thickness (t). Typical Dk/t values are given for the centre thickness of a -3D SCL. There is no information about Dk/t for the centre or peripheral thicknesses of other dioptric powers. However, these are important too, because there is no lateral diffusion under thicker areas [1][2], so this can also induce characteristic signs of hypoxia [3][4]. In that fact oxygen supply could be estimated much better by generating a thickness profile of the complete SCL.

Purpose:

Primary objective was the characterization of thickness profiles and lens stabilization systems of eight toric SCL brands and the generation of oxygen maps to visualize the Dk/t values of two new launched silicone hydrogel contact lens (SHCL) brands *in vitro*. Another aim was to avoid dyeing the lenses like in previous studies to get results, which are comparable to the measurements with the cutting method and using the microscope.

Methods:

***Scheimpflug* method:** A modified *Scheimpflug* camera (*Pentacam, Oculus*) was used to measure 18 spherical SHCL in a range from +6D to -12D and 63 toric SCL (n=33 SiHy; n=30 non-SiHy) from -1D to -6D with a cylinder of -0.75D up to -1.75D. With a rotating slit light of the camera, exact cross-sections of the SCLs were generated to create a colour-coded topographic map by calculating 138,000 real altitudinal data. To generate Dk/t maps the thickness profiles were combined with the Dk value of the manufacturer`s specification.

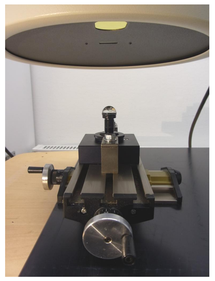

Fig. 1: Spherical glass calotte, the seat area for the SCL, on a desk for adjustment under the *Scheimpflug* camera

In case of a fail surface detection, the SCLs were dyed for five minutes with a solution of $2 \cdot 10^{-3}$% sodium fluorescein.

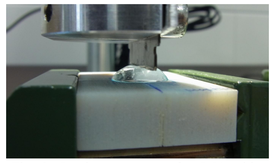

Fig. 2: Cutting process of a SCL with two clamped razor blades

Cutting method: To compare the results, every lens was cut into a thin profile slide, which includes the thickest and thinnest area of the SCL, and examined under a microscope (*Zeiss Axio Vision Software,* Fig. 15).

Results:

- **Visualization of different thickness profiles of toric SCL (examples)**

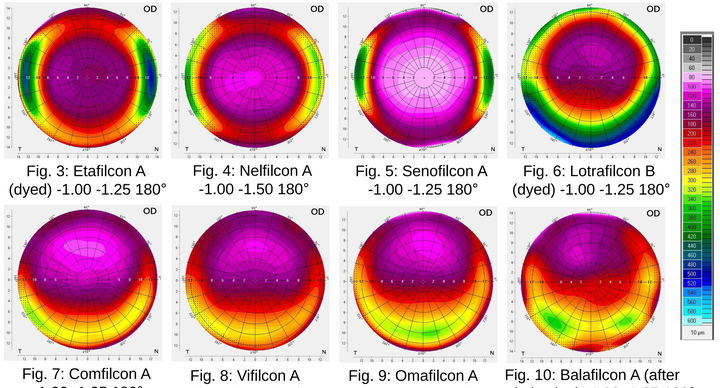

Fig. 3: Etafilcon A (dyed) -1.00 -1.25 180°
Fig. 4: Nelfilcon A -1.00 -1.50 180°
Fig. 5: Senofilcon A -1.00 -1.25 180°
Fig. 6: Lotrafilcon B (dyed) -1.00 -1.25 180°
Fig. 7: Comfilcon A -1.00 -1.25 180°
Fig. 8: Vifilcon A -1.00 -1.00 180°
Fig. 9: Omafilcon A -1.00 -1.25 180°
Fig. 10: Balafilcon A (after optimization) -1.00 -1.25 180°

- **Visualization of thickness profiles and oxygen maps of new launched SHCLs (examples)**

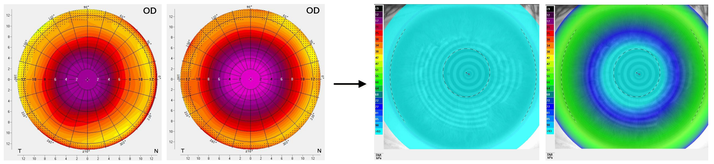

Fig. 11: Delefilcon A (dyed) -3D
Fig. 12: Balafilcon A (dyed) -3D
Fig. 13: Oxygen map of Delefilcon A -3D
Fig. 14: Oxygen map of Balafilcon A -3D

- **Generated thickness profile by using cutting method and microscopy**

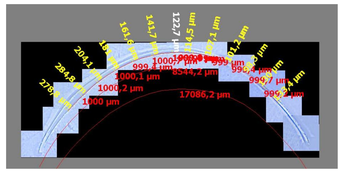

Fig. 15: Example of a cutted profil slide of Lotrafilcon B -1.00 -0.75 180°, examined under a microscope

- **Optimization of the *Scheimpflug* technology**

After modification the *Scheimpflug* camera detects thickness values of an area more than 14mm diameters without dyeing the lenses.

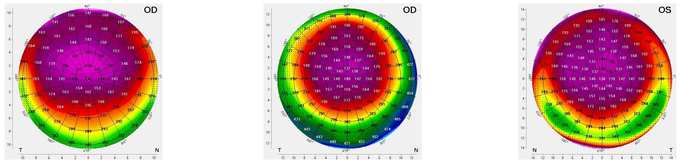

Fig. 16: Before optimization without dyeing and less (fail) detected surface, Lotrafilcon B -3.00 -1.25 180°
Fig. 17: Before optimization with dyeing and increased thicknesses, Lotrafilcon B -3.00 -1.25 180°
Fig. 18: After optimization without dyeing and finer surface detection, Lotrafilcon B -3.00 -1.25 180°

- **Comparison between the results of the *Scheimpflug* and cutting method**

There is a significant positive linear correlation (r_{max}= 0,983, p<0,001, r_{min}= 0,297, p=0,066) between the *Scheimpflug* and cutting method, when lenses were not dyed and with dyeing the lenses (r_{max}= 0,941, p<0,001, r_{min}= 0,791, p<0,001).

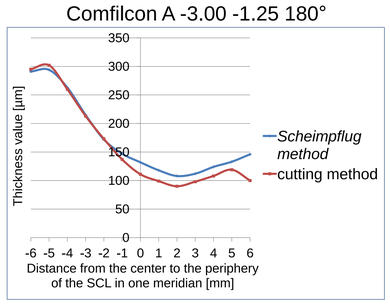

Fig. 19: Comparison of the thickness values between *Scheimpflug* and cutting method of Comfilcon A -3.00 -1.25 180° without dyeing the lens

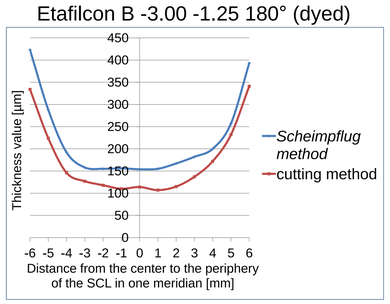

Fig. 20: Comparison of the thickness values between *Scheimpflug* and cutting method of a dyed SCL, Etafilcon B -3.00 -1.25 180°

Discussion:

Thickness profiles and oxygen maps were generated successfully. However, it is necessary to continue doing comparison measurements by using the cutting method to control the results. There was seen a clear effect of increase in thickness values (Fig. 20), when SCL were dyed. This effect could be eliminated by optimizing the *Scheimpflug* camera.

Conclusion:

The thickness profiles can be used to characterize designs of SCLs and to visualize the oxygen transmissibility over the entire area of various lens types without dyeing. The better knowledge about the oxygen supply through the SCL can protect the eye from the impact of hypoxia, which still remains as a motivation for continuing studies.

References:

[1] FATT I., WEISMANN B.A., RUBEN C.M.: Areal Differences in Oxygen Supply to a Cornea Wearing an Optically Powered Hydrogel Conact Lens. CLAO J., 1993; 19(4):226-234
[2] EFRON N., FRITZGERALD J.P.: Distribution of Oxygen Across the Surface of the Human Cornea during Soft Contact Lens Wear. Optom Vis Sci, 1996; 73(10):659-665
[3] HOLDEN B.A., MERTZ G.W.: Critical Oxygen Levels to Avoid Corneal Edema for Daily and Extended Wear Contact Lenses. Invest Ophthalmol Vis Sci, 1984; 25(10):1161-1167
[4] HARVITT D.M., BONANNO J.A.: Re-evaluation of the Oxygen Diffusion Model for Predicting Minimum Contact Lens Dk/t Values Needed to Avoid Corneal Anoxia. Optom Vis Sci, 1999; 76(10):712-719

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