OXYGEN TRANSMISSIBILITY OF VARIOUS SILICONE HYDROGEL CONTACT LENSES

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PURPOSE

To determine and generate oxygen transmissibility (Dk/t) profile maps across various contact lenses in different powers.

Oxygen transmissibility is defined as the oxygen permeability (Dk) of a certain material divided by the lens thickness (t) at a given location. Traditionally, transmissibility was quoted as a single value only, referring to the center thickness of a –3.00D lens of a given lens type. While providing some relative comparison between lens types, this value does not reflect the clinically more relevant differences across the power range and averaged Dk/t measures for central and peripheral areas.

Although, there are still different opinions on what minimum transmissibility is required to maintain a healthy eye, the two benchmark values set by Holden & Merz[1] (87units) and Papas[2] (125 units) to avoid overnight corneal oedema and limbal redness respectively, are now widely accepted.

METHODS

Lenses: 4 different silicone hydrogel lens types and materials were investigated for this study:

- PureVision – balafilcon A
- Acuvue Advance – galyfilcon A
- Focus Night & Day – lotrafilcon A
- O2Optix – lotrafilcon B

Of each lens type, two lens powers, -3.00D and +3.00D were measured. All lenses were stored in ISO standard PBS for at least 24 hours prior to any measurements.

Thickness Measurements: A custom built thickness profiler was used to obtain thickness profiles of all lens types and powers. Five lenses in each group were measured in four meridians and all the thickness profiles averaged. In addition, the center thickness of all lenses was measured in accordance with ISO 9339-2[3] and thickness profiles adjusted to comply with those results

Oxygen Permeability Measurements: As there is no valid international standard for measuring oxygen permeability of high Dk silicone hydrogel lens materials, the method described in ISO 9913-2[4] was adapted in conjunction with a modified DK1000 coulometric oxygen apparatus (JDF Company, GA, USA) to determine the Dk value of the four silicone hydrogel materials. Permeability measurements were performed on five lenses of –1.00D power in each lens material.

Oxygen Transmissibility: From the measured thickness profiles and Dk values, the transmissibility profiles were calculated for each lens type and power. In order to obtain mean peripheral and central oxygen transmissibility, the material specific permeability was divided by the harmonic mean thickness of each lens, as calculated for the central 8 mm diameter and for the peripheral 8 to 14.2mm annular ring area.

Table 1: Measured Oxygen Permeability

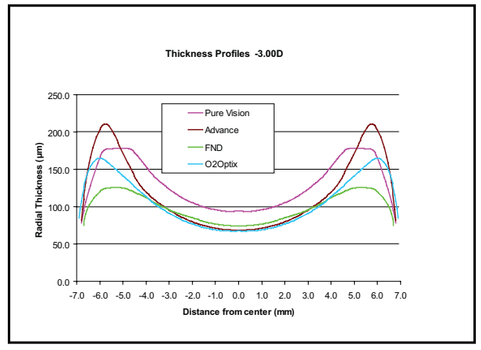
	Measured Dk $x10^{-11}$[cm²/sec]*[mlO2/(ml*mmHg)]	STDEV
PureVision	104	10.0
Acuvue Advanced	77	1.6
Focus Night & Day	163	18.0
O_2OPTIX	114	6.7

Table 2: Harmonic mean thickness and transmissibility for central and peripheral areas

	-3.00 D			+3.00 D		
	Center Thickness	Harmonic mean thickness		Center Thickness	Harmonic mean thickness	
	µm	0-8mm diam. µm	8-14.2mm diam. µm	µm	0-8mm diam. µm	8-14.2mm diam. µm
PureVision	93.9	120.2	152.0	132.2	98.4	91.6
Acuvue Advanced	68.8	92.4	161.9	153.6	119.5	160.6
Focus Night & Day	75.0	93.4	107.8	149.2	117.4	99.3
O_2OPTIX	67.6	88.4	143.3	128.9	94.6	133.6

	-3.00 D			+3.00 D		
	Center Dk/t	Harmonic mean Dk/t		Center Dk/t	Harmonic mean Dk/t	
		0-8mm diam.	8-14.2mm diam.		0-8mm diam.	8-14.2mm diam.
	x10-9[cm/sec]*[mlO2/(ml*mmHg)]			x10^{-9}[cm/sec]*[mlO$_2$/(ml*mmHg)]		
PureVision	111	86	68	79	106	114
Acuvue Advanced	112	83	48	50	64	48
Focus Night & Day	217	174	151	109	139	164
O_2OPTIX	169	129	80	88	120	85

Figure 1: Thickness Plots for –3.00D and +3.00D Lenses



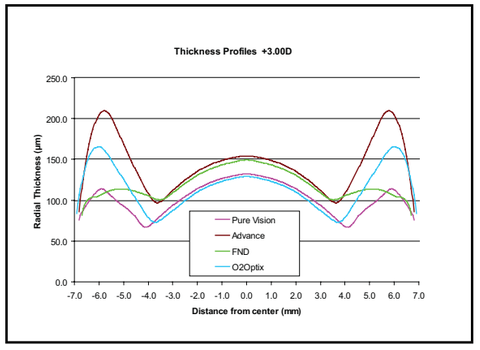
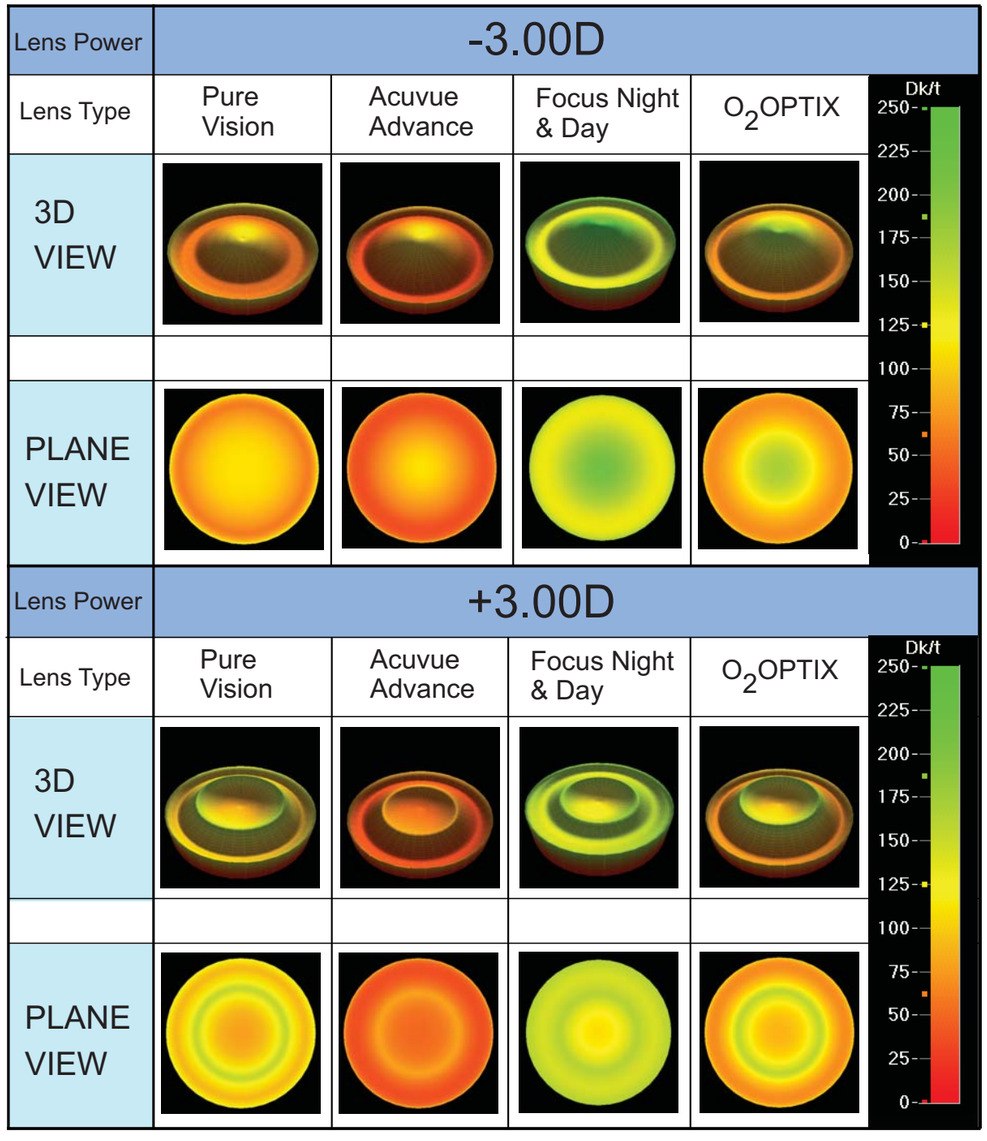


Figure 2: Oxygen Transmissibility – Color coded 3D and plane views



RESULTS

The results for the Dk measurements are listed in Table 1. Measured values are generally (up to 23 units) higher than nominal parameters as published by the manufacturer. Averaged thickness profiles for all lens types are shown in Figure 1 for the +3.00D and –3.00D lenses.

The transmissibility profiles were converted into colour coded 3-D and plane view maps to illustrate areas of high and low transmissibility (Figure 2). Areas of green are elevated and correspond to higher transmissibility, demonstrating differences between lens types and designs, as well as across the power range. The central and peripheral areas had been quantified and the mean thickness and transmissibility summarised in Table 2. For the –3.00D Acuvue Advance lens Dk/t dropped from 83 at the optical zone to 48 in the periphery. However, FND lens maintained a relative constant Dk/t of 174 to 151 respectively. PureVision lenses showed the greatest difference in peripheral Dk/t, 68 for the -3.00D and 114 for the +3.00D lens. In contrast, the peripheral Dk/t for Acuvue Advance is consistent (48) for both lens powers.

CONCLUSIONS

Contact lenses made from the same material in different shapes supply different amounts of oxygen to the cornea. Dk/t based on center thickness of a -3.00D lens is unrepresentative of physiological performance. A more relevant measure is to calculate the area-weighted mean transmissibility. Practitioners can assess lens oxygen supply by referring to average Dk/t across the optical or the peripheral zone.

Peripheral lens design has a significant impact on the mean transmissibility outside the optic zone. For most contact lenses, this peripheral annular ring area is twice the size of the central optic zone, making it a major contributing factor for the overall oxygen supply to the anterior eye.

ACKNOWLEDGEMENTS

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