Comparison of four commonly used semi-scleral contact lenses: average thickness, transmissibility (Dk/t), lens profile and settling characteristics

Grant A Watters MSc Optom DipCLP FCLS

Optometrist

Department of Optometry and Vision Science, University of Auckland, Auckland, New Zealand

(**Disclosure**: this independent research was sponsored by Menicon Co. Ltd)

New Zealand/Aotearoa
(pop. 4.5 million)

- High prevalence of keratoconus [1]
- Seems over-represented in indigenous Maori & immigrant Pasifika populations [2]
- NZ Govt. subsidises CL fitting
- Lots of research going on… [3]

1. Owens H et al. Topographic indications of emerging keratoconus in teenage New Zealanders. Cornea 2007; 26: 312-318
2. Jordan CA et al. Computerised corneal tomography and associated features in a large New Zealand keratoconic population. J Cataract Refract Surg 2011; 37:1493-1501
3. Special issue: Keratoconus. Clin Exp Optom 2013; 96:2

Do RGP Semi-Scleral lenses meet corneal oxygen criteria? **(Fatt H/M 24 cent.; H/B 35 periph.)**

- Measuring average CL thickness and taking post-lens tear film into account gives a truer picture- "resistor series" [4]

$$\mathbf{Dk/t\ (system) = \ 1/(t1/Dk1)_{CL} + (t2\ /Dk2)_{TF}}$$

- Average CL thickness can theoretically be calculated by weighing it, and solving for surface area (volume) and specific gravity of the material using the formula:

T (ave) = mass/vol. x density [5, 6]

Vol (ellipse) = $4/3\pi$ ht r1 r2 -if know sag or $V = 2\pi a^2(1 + b/ac \sin^{-1}e)$ -if know ecc.

Vol (sphere) = $4/3\ \pi r^3$

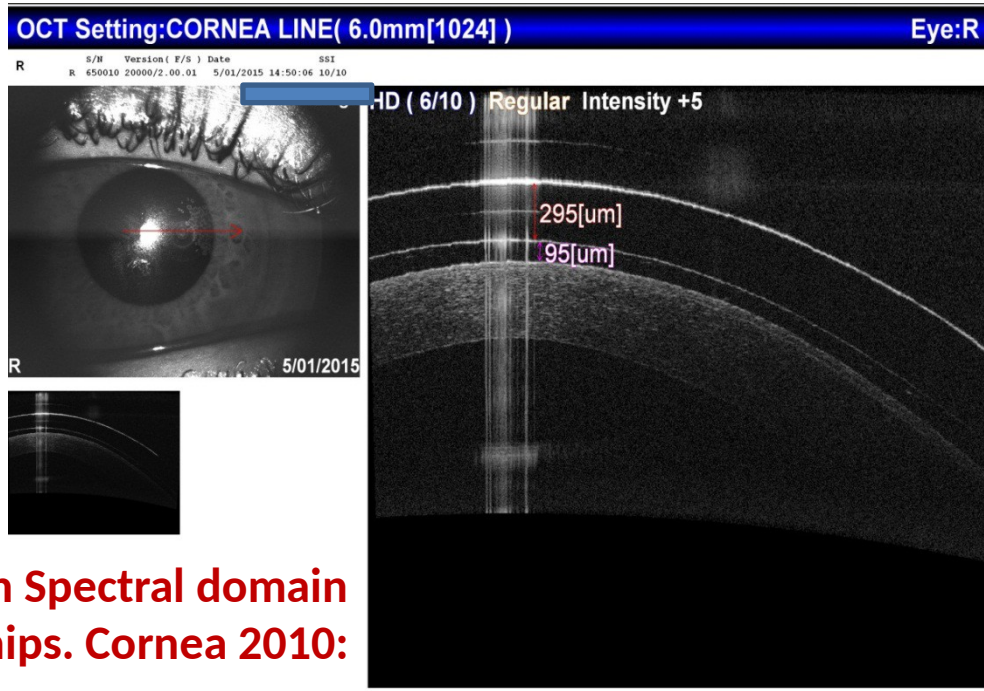
4. Michaud L et al. Predicting estimates of oxygen transmissibility for scleral lenses. Contact Lens Ant. Eye 2012;35: 266-271

5. DeDonato Larry M. Determination of the average thickness of a contact lens. Am. J. Optom. Physiol. Optics 1981; 58:10: 846-847

6. Weissman Barry A. Mass of Rigid Lenses. Am J Optom. Physiol. Optics 1985; 62:5: 322-328

3 ways to measure average CL thickness

- Old school CT gauge (accuracy?)
  center thickness/limbal thickness/max. thickness/edge thickness, and then average out
- Anterior OCT calipers [7] (reflections?)
- Use a clever formula [5,6] (complex?)



7. Gonzalez-Meijome JM et al. High-resolution Spectral domain technology to visualise CL to cornea relationships. Cornea 2010: 29;12:1359-1367

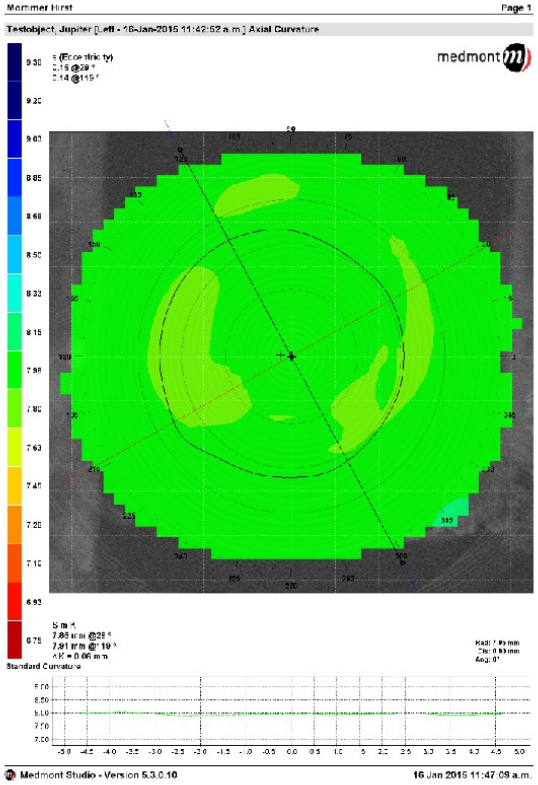
4 different SS lens designs measured, all manufactured in Dk100 material

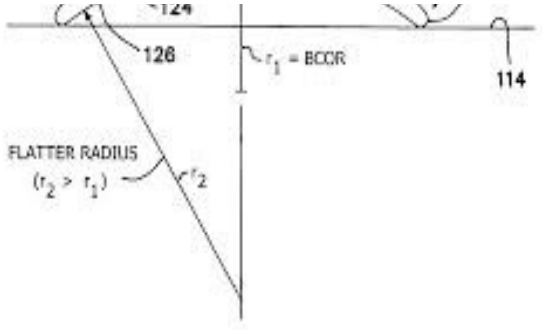
Equiv BC = 6.80 ; power = -8.00 ; nearest diam. to 14.6

Lens design (manufacturer) Diam. ǂ /Material	BCOR mm (meas./ ordered	CT mm (gauge)	CT µm (OCT)	OZD mm (meas. loupe)	Periph./blend (meas. loupe)
ICD (Paragon) 16.5mm /HDS	6.89/ 6.89	0.30	295	8.6	7 zone/medium
OneFit (Blanchard) 14.6mm/BXO	6.82/ 6.80	0.28	270	8.1	6 zone/light
Rose K2 XL (Menicon) 14.6mm /BXO	6.79/ 6.80	**0.15**	**151**	8.2	5 zone/medium
SoClear (Dakota) 14.6mm /BXO	6.78/ 6.80	0.18	174	7.8	4 zone/heavy

ǂ **Diameters as available from the manufacturer**

Measuring the lens elements to get volume for a calculated ave. thickness



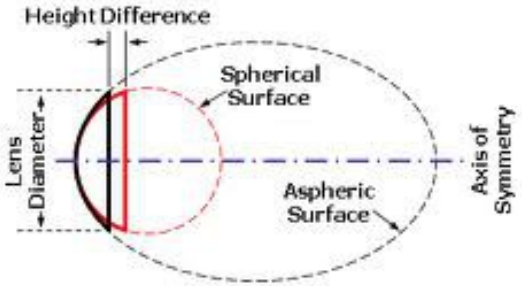


- FSR & FSD & eccentricity off topographer so can calc. FSV ½-volume at diameter chord
- we know the CT and ET of each design (OCT/gauge)- but sag not provided
- BSR & BS diam. of optic is known but not exact periph. curves to get BSV ½-volume

**Assumptions: FS is flattening monocurve? BSR is spherical? PC's averaged.

LENS	FSR (mm)	ECC.
ICD	8.05	e=0.60
OneFit	8.00	e=0.40
RoseK2XL	7.90	e=0.45
SoClear	7.80	e=0.40

e = 0 (circle)
e = 1.0 (high ellipse)



Aspheric Versus Spherical Surface

Lens mass, ave. thickness and ave. Dk/t

(T (ave) = mass/vol x density) SG BXO=1.19 ; SG HDS=1.10

ǂ Satisfies Holden & Mertz (H/M) criteria of 24 Fatt units for central cornea

\# Satisfies Harvitt & Bonnano (H/B) criteria of 35 Fatt units for peripheral cornea

Lens design (manufacturer) Diam. (Rec. tear thickness)	Mass (mg) (material)*	Calc. ave. Thickness	Ave. Lens Dk/t (Fatt)	Ave. thick. (gauge)
ICD (Paragon) 16.5mm (300- 400πm)	112.5 (HDS)	**0.35mm 350πm**	28.6 ǂ	0.37
OneFit (Blanchard) 14.6mm (100-250πm)	81.4 (BXO)	**0.34 340πm**	29.4 ǂ	0.35
Rose K2 XL (Menicon) 14.6mm (20-50πm)	**53.6** (BXO)	**0.20 200πm**	**50.0 ǂ #**	0.20
SoClear (Dakota) 14.6mm (50-100πm)	93.3 (BXO)	**0.31 310πm**	32.3 ǂ	0.31

* All measurements taken 3 times and averaged

Settling characteristics and postlens tear film measurements

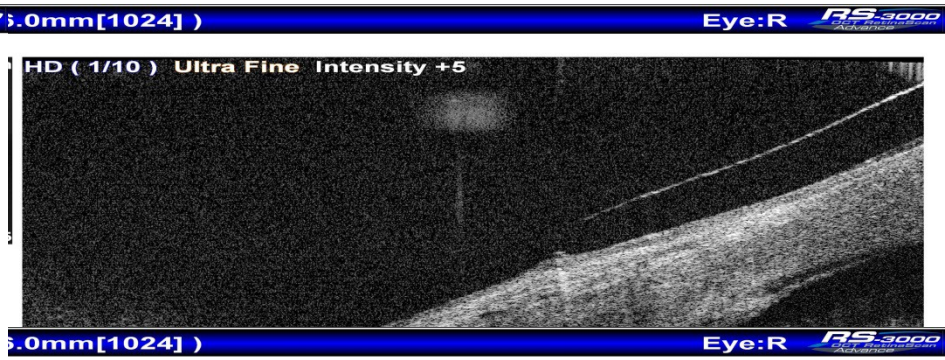
Lens design (manufacturer) & rec. fitting clearance	Postlens tear film thickness * (ave thickness- if 10πm at limbus)	Ave. lens thickness µm/Dk/t	Dk/t of total system center/limbus/ave (Fatt)
ICD (Paragon) 300-400µm	95 (53)	350/28.6	**24.2 ǂ/24.2ǂ/24.0 ǂ**
OneFit (Blanchard) 100-250µm	341 (176)	340/29.4	**14.4/25.5ǂ/17.8**
Rose K2 XL (Menicon) 20-50µm	75 (43)	200/50.0	**62.7 ǂ #/45.2ǂ #/48.7ǂ #**
SoClear (Dakota) 50-100µm	512 (261)	310/32.3	**12.3/34.2ǂ/15.7**

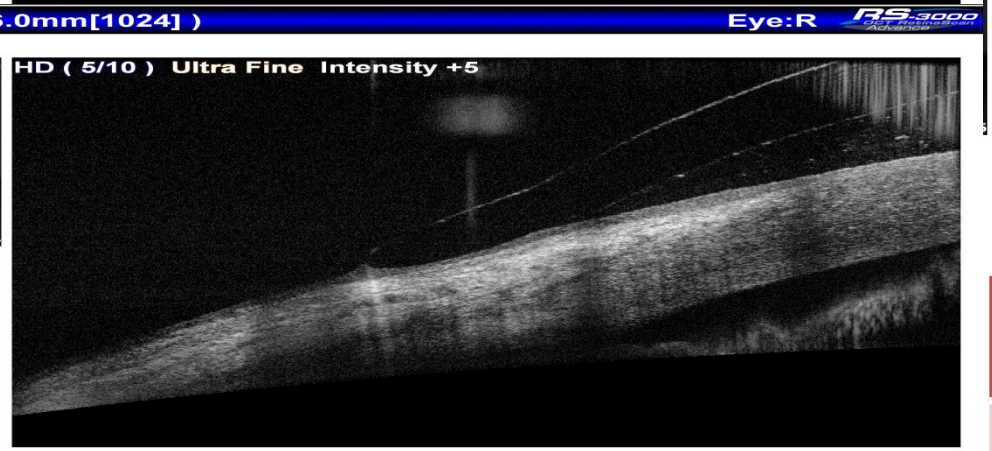
* As measured with a Nidek RS-3000 Advance OCT after 1 hour

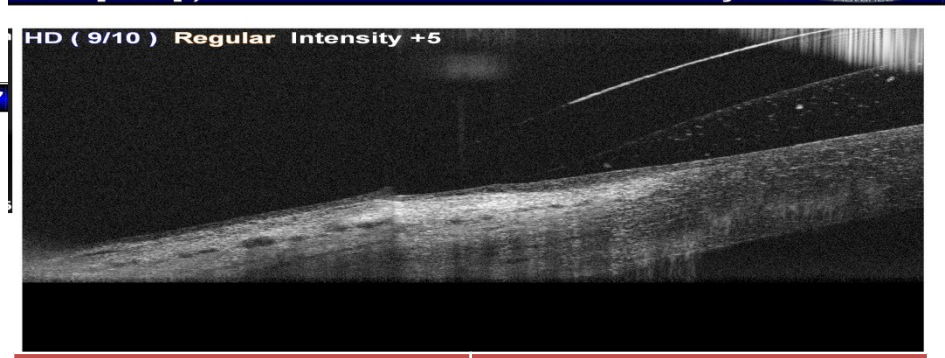
ǂ Satisfies Holden & Mertz (H/M) criteria of 24 Fatt units for central cornea

\# Satisfies Harvitt & Bonnano (H/B) criteria of 35 Fatt units for peripheral cornea

Lens profiles and subjective comfort rating (CR) for an adapted SS wearer







ICD CR 10/10 (Top left)	**RoseK2XL CR 9/9 (Top right)**
Onefit CR 9/9 (Bottom left)	SoClear CR 8/9 (Bottom right)

Conclusions

- "If using Dk 100 material the average CL and tear film combined thickness needs to be 350 microns or less to satisfy the H/M and H/B criteria (eg lens CT 250µm + TF 100µm)" [4]
- **Should we be using higher Dk materials for semi-scleral lenses?**

  (eg BXO2=141; MenZ= 163)
- The 4 designs sampled had large differences in average lens thickness and vault/tear film thickness for supposedly the same fitting parameters
- Controlling tear film thickness (Dk80) is important- 100µm or less?
- Anterior OCT is a useful tool for assessing semi-scleral lenses (sag?)
- **Can we measure average lens thickness using a formula?????**
- Does the keratoconic cornea have "normal" oxygen demand? ("sippers"- normal endothelium but reduced stromal mass??) [8]

4. Michaud L et al. Predicting estimates of oxygen transmissibility for scleral lenses. Contact Lens Ant. Eye 2012;35: 266-271

8. Owens H, Watters G, Gamble G. Effect of Softperm lens wear on corneal thickness and topography: a comparison between keratoconic and normal corneae. CLAO J 2002;28: 83-87

Acknowledgements

- Thanks to Dr Paul Rose, Emilie Langley, px MS, Dr Phil Turnbull (Auckland Optometry), & Kurtis Brown & Dr Jennifer Choo from Menicon for helping me with this project!