Finding the Right Balance: A Keratoconus Fitting Challenge after Cataract Surgery

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Background

In the past few decades, there has been an exponential increase in patients with Keratoconus being fit with scleral lenses with successful comfort, visual potential and therapeutic benefit. As this group continues to expand, these same patients will eventually age bringing on the need for cataract extraction. Majority of these patients will likely benefit from wearing a scleral lens post cataract surgery and therefore, require a refitting with alterations in lens parameters, power and design altogether. This case illustrates the process of re-fitting a Keratoconic patient who recently went through cataract extraction, with emmetropia targeted in the intra-ocular lens.

Case Description

An 81-year-old Caucasian male presents for a scleral lens re-fitting after undergoing cataract surgery in his left eye 3 months prior. He has an ocular history of Keratoconus OS>OD, Age-related Cataract OD and Pseudoexfoliation Syndrome. Furthermore, he is an established scleral lens wearer for the past 10 years and is currently wearing the MSD design in his right eye only. Prior to cataracts, the patient's best corrected visual potential with scleral lenses was 20/40 OD, 20/40 OS.

Entering Visual Acuity:
OD cc 20/50^{+2} PH NI (wearing MSD 4.70/7.40/-1.00/15.8/F1/0.33/XO2)
OS sc 20/200 PH 20/80

Refraction:
OS: +5.75-6.00x160 20/100

Figure 1: Left image illustrate baseline corneal staining with no history of scleral lens for 3 months, right image illustrates central nipple cone OS obtained at initial baseline visit

Initial Diagnostic Scleral Lens:
MSD 4.80/Std /-1.00/15.8/F1/0.34/XO2

- Theoretically, this same lens design should provide a suitable fit and simply the lens power would need to be adjusted post cataract surgery
- *Immediately after application*: central clearance 350 um, midperiphery 450 um, limbus 150 um with 360 degrees of scleral blanching

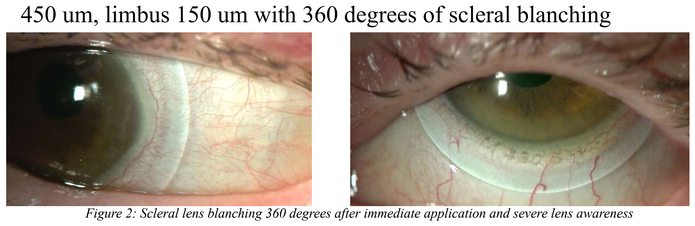

Figure 2: Scleral lens blanching 360 degrees after immediate application and severe lens awareness

Second Diagnostic Scleral Lens:
OneFit MED 4400/8.0/-1.50/15.6/M, L, E Std/0.24

- This product was chosen due to the thinner lens design and flexibility in customizing midperipheral, limbal and edge curves by 25 um steps without compromising central vault
- *Immediately after application*: central clearance 250 um, midperiphery 400 um, limbal 150 um, no scleral blanching or compression 360 degrees
- *After 1 hour of settling*: central clearance 150 um, midperiphery 300 um, limbal 100 um, no scleral blanching or impingement, comfort 10/10

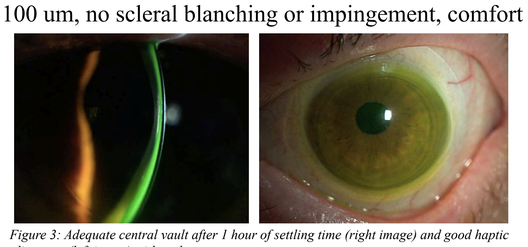

Figure 3: Adequate central vault after 1 hour of settling time (right image) and good haptic alignment (left image) with no lens awareness

Visual Assessment:

- Over-refraction: +12.50 sph 20/50^{-1}
- Using the OneFit MED fitting calculator (Optimum Extreme dk = 125):
  - Lens Thickness 630 um
  - Tear Layer Thickness 150 um
  - Estimated Dk/t 14

*Formula : dk = (1/((Lens thickness/Material Dk)+(Tear thickness/80)))*100

IOL Calculations

IOL Effective Power (OS):

- The following was obtained through the surgeon's notes:
  - Keratometry 53.07/58.09
  - IOL Master/A-Scan: 25.74 mm
  - IOL (Alcon) power implanted: -1.0 D, 13 mm length, 8.0 mm optic
  - Goal: Target patient for functional uncorrected vision

Troubleshooting Lens Design

Customize Lens Design:

- Goal: To allow as much oxygen permeability as possible
  - Maintain thin lens design through center thickness
  - Maintain minimal yet adequate central clearance
- Method: Create lens with 4400 SAG + Steep 6.4 BC (instead of 8.0 BC)

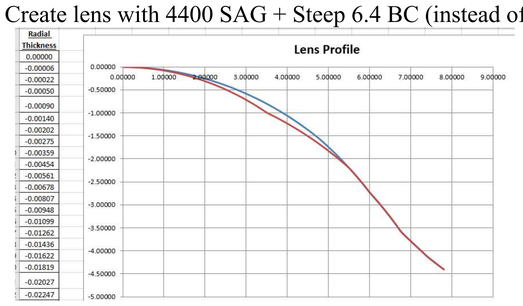

Figure 4: Red line demonstrating 6.4 mm steeper base curve change at the midperipheral profile at an optic zone diameter of 7 mm, blue line illustrates original lens with 8.0 mm flatter base curve

Initial Scleral Lens Assessment:
OneFit MED: 4400/6.40/+1.87/15.6/STD PC/0.25/Optimum Extreme
VA cc 20/50+ Over-refraction +1.00-0.75x080 20/40
Comfort 9/10, Average Wear Time: 13 hours

- Patient reports of intermittent ghosting and irritation with contact lens removal
- *After 5 hours of wear time today:*
  - Central clearance 150 um, midperipheral 250 um temporal, inferior, superior however zone of touch nasal midperiphery, 50 um limbal
  - Nasal fluorescein staining and microcystic edema with lens removal

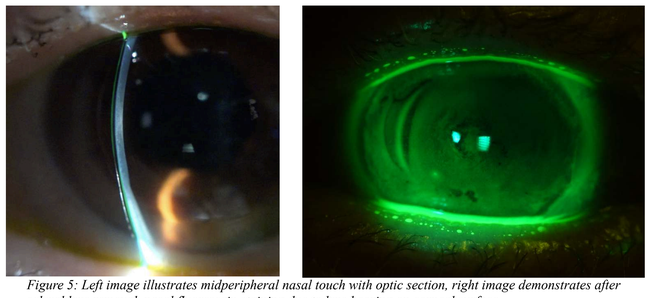

Figure 5: Left image illustrates midperipheral nasal touch with optic section, right image demonstrates after scleral lens removal, nasal fluorescein staining due to lens bearing on corneal surface

Troubleshooting Lens Design:

1) Quadrant Based Design

- Increase nasal midperiphery to prevent lens bearing
- However, resultant lens would require flatter base curve and therefore, increase lens thickness to 650 um

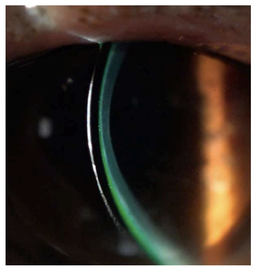

Figure 6: Optic section demonstrates large scleral lens center thickness (650 um) compared to 250 um post-lens clearance

2) Fit with Higher Sagittal Height

- This design would result in a larger amount of central and midperipheral clearance while also maintaining a steeper base curve for a thin lens design in the setting of a high plus lens power

Final Lens OS:
OneFit MED 4550/6.4/+4.00/15.60/M, L, E Std/Optimum Extreme/0.40
VA cc 20/50 Comfort 10/10

- Adequate vault (150 um)
- Good haptic alignment
- Estimated Dk/t 20

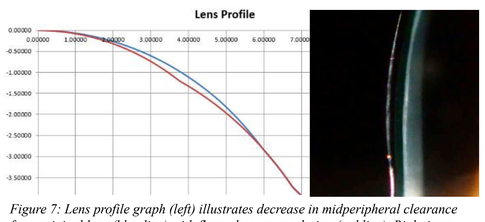

Figure 7: Lens profile graph (left) illustrates decrease in midperipheral clearance from original lens (blue line) with flatter base curve design (red line). Right image demonstrates adequate clearance over nasal midperiphery.

Treatment and Management

- Oxygen permeability through contact lenses has been a highly discussed and researched topic in order to determine critical levels
- The Holden-Mertz Criteria (1984)[6] suggests that with hydrogel lenses the minimum Dk/t for daily wear is 24, while extended wear is 87
- The Harvitt-Bonanno Criteria (1999)[6] claims to prevent corneal hypoxia, Dk/t levels of 35 in open eye states and 125 in closed eye
- Michaud (2012)[5] established the following formula to determine the dk/t for a scleral lens: $\frac{Dk}{t_{scl}} = \frac{1}{(t_1/Dk_1)+(t_2/Dk_2)}$
- Lens material plays a crucial role in oxygen permeability. The following is a list of commonly used materials in scleral lenses; Tyro 97 Dk=97, Optimum Extra dk=100, Boston XO dk=100, Optimum Extreme dk=125, Boston XO2 dk=141, Menicon Z dk=163 [3,4,7]
- A study in 2012 conducted by Michaud et al concluded that the highest Dk scleral lens (>150) should be maintained through a maximum central thickness of 350 um and central clearance of 200 um[5]

Dk=150	Clearance (μm)	100	150	200	250	300	350	400
Lens thickness (μm)								
250		34.3	28.2	24.0	20.9	18.6	16.6	15.0
300		30.8	25.8	22.2	19.5	17.4	15.7	14.3
350		27.9	23.7	20.7	18.3	16.4	14.9	13.6
400		25.5	22.0	19.3	17.2	15.6	14.2	13.1
450		23.5	20.5	18.2	16.2	14.8	13.5	12.5
500		21.8	19.2	17.1	15.5	14.1	13.0	12.0

: satisfies HM criteria
: satisfies HM and HB criteria

Figure 8: Comparing oxygen permeability through varying amounts of clearance and lens thickness for a lens material with Dk = 150[5] (Image adapted from Michaud et al)

- Compan et al (2014) suggests that thinner lens vault (150 um) achieves a partial pressure of 55 mmHg necessary for oxygen permeability[1, 2]
- Clinical practitioners however suggest that the risk of scleral lens touch outweighs the benefit of maintaining a thinner lens vault and there is minimal evidence of corneal neovascularization due to higher clearance
- Due to the flexibility of lens design and fitting larger diameters, tear exchange is another crucial factor contributing to oxygenation of the cornea

Clinical Pearls

- This case study illustrates the importance of communicating with cataract surgeons in regards to the IOL refractive target in patients with Keratoconus, especially if a specialty contact lens is expected to be worn post surgery
- Theoretical evidences proves that maintaining a thinner post-lens clearance layer is crucial to allow higher amounts of oxygen permeability
- During initial fittings, discretion should be used to ensure that the corneal vault is not too excessive
- Incorporating in-office settling time into initial fittings and using OCT technology to measure clearance amounts can provide more accurate measurements and prevent the quantity of lens remakes
- Clinicians should advise patients with thinner lens designs and higher Dk materials to be aware of the risk of lens warpage and breakage, therefore, lens handling should be completed as delicate as possible
- Customizing commercial scleral lenses can be completed with the support of consultation staff in order to maintain thinner lens designs
- Consider drawing attention to maintaining thinner lens designs in cases where oxygen permeability is crucial; Corneal transplants, Aphakia, Advanced Keratoconus and Ocular Surface disease

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