Scleral Topography-Guided Scleral Lens Fitting

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Abstract
Keratoconus is a progressive corneal ectatic disease that leads to corneal shape irregularity and subsequent blur, visual distortion, and glare. One of the best non-surgical treatments for those suffering from keratoconus are scleral lenses. The ability of scleral lenses to compensate for irregular astigmatism allows patients to see clearer, more comfortably, and with visual stability. Technological advances such as sMap3D scleral topography allow for a more precise first lens, which enhances initial comfort and vision, all while reducing chair time. Despite technological guidance, considerations must still be made to conjunctival settling, corneal edema, and corneal hypoxia.

Introduction
Keratoconus is a bilateral, progressive corneal disease in which stromal ectasia leads to structural irregularity of the cornea. The progressive corneal distortion results in blurred vision, glare, and potential corneal scarring. Traditional studies relying on corneal signs and irregular retinoscopy reflex place the prevalence of keratoconus as approximately one out of 2,000,1 but more recent studies show one out of 375.2 The average diagnosis of keratoconus is made in the second decade of life.3 With technological improvements in early-detection, corneal/scleral topography, and lens designs, clinicians can more effectively treat and reduce visual sequelae secondary to keratoconus.

Case Report
A 30-year-old Hispanic male JR presented to the clinic on 11/12/2018 for a comprehensive exam and a consultation for an alternative to corneal gas permeable (GP) lenses. JR reported longstanding discomfort and blur with his three-year-old GPs and had discontinued wear for two months. JR was previously diagnosed with bilateral keratoconus in 2015 and had bilateral corneal-crosslinking performed in 2017 to aid in stabilizing further ectasia. He was not taking any medications, had no known medical conditions or drug allergies, and had an unremarkable family medical history. Pupil function, ocular alignment/motilities, confrontational fields, and intraocular pressures (11/14mmHg) were all within normal ranges.

Anterior segment evaluation revealed findings consistent with keratoconus. Found were elements of bilateral inferior thinning with Vogt’s striae in the inferior aspect of the cornea, but with the absence of scarring. His anterior segment was otherwise within normal limits. With a dilated fundus examination, both eyes revealed a healthy posterior pole and periphery. Refractive data follows:

Manifest Refraction:
OD: +2.75-1.50x145 BCVA: 20/60
OS: -4.75-1.50x115 BCVA: 20/80

Keratometry Values:
OD: 50.6D @ 014 deg, 47.2D @ 104 deg
OS: 52.9D @ 137 deg, 51.7D @ 047 deg

An Oculus Keratograph 5m was used to capture corneal topography (see Figure 1), with the sMap3D providing the scleral topography data (see Figure 2). The sMap3D’s composite mapping of the three directions of gaze (primary, superior, inferior) allowed for a complete scan of the ocular surface devoid of eyelid interference. An additional benefit of the sMap3D’s software was the suggested starting sagittal depth of the first diagnostic fitting lens, which allowed for streamlining of the fitting process. After the insertion of a trial lens that best approximated the suggested sagittal height, the over-refraction data was then combined with the composite mapping to create a customized mini-scleral lens.

Given the sMap3D software’s initial suggested sagittal height of 300µm of central clearance, the following diagnostic trial lenses were chosen:

Europa Diagnostic Trial #1:
OD: Europa Dx Lens #3, Sagittal Height 4470µm
OAD 16.0mm, BC 44D, CLP -1.00D
OS: Europa Dx Lens #2, Sagittal Height 4390µm
OAD 16.0mm, BC 43D, CLP -0.50D

With the lenses in place, an over-refraction was taken:
OD: -9.25, VA 20/25-
OS: -11.50, VA 20/25-

The diagnostic lens parameters, the over-refraction data, and composite mapping were then submitted to the laboratory.

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Europa #1 - Initial Lens Dispense
OD: CLP -7.37D, BC 42D, OAD 15.8mm, CT 0.28mm, Sag 4469µm, spherical back surface
PC1 6.71mm/2.00mm, PC2 9.5mm/0.75mm
PC3 13.5mm/0.5mm, PC4 14.5mm/0.4mm

OS: CLP -11.63D, BC 44D, OAD 15.8mm, CT 0.25mm, Sag 4437µm, 196µm back surface toric
PC1 6.93mm/2.00mm, PC2 9.5mm/0.75mm
PC3 13.5mm/0.5mm, PC4 14.5mm/0.4mm

*In Visionary Optics nomenclature, PC1-PC4 refers to the peripheral curves from the limbus on towards the lens edge. The first number represents the radius of curvature, e.g. 6.71mm. The second number represents the width of that curve, e.g. 2mm. For lenses with toric peripheral curves, the toric peripheral curves extend throughout PC2, PC3, and PC4.

Upon insertion of JR’s first set of mini-sclerals, he found his vision to be clear with 20/20- OD and 20/25- OS. Sagittal height was assessed with a comparison between the thickness of the fluorescein-stained tear reservoir and the central thickness of the lens. Central clearance was 400µm OD and 375µm OS upon insertion, with the values reduced to 280µm OD and 250µm OS after a four-hour return to the office to examine the post-insertion settling. A -0.25D over-refraction was noted over both lenses. Rotationally, the OS mini-scleral was aligned with the proper 3-6-9 o’clock markings, whereas the OD mini-scleral had a spherical back surface. JR’s OD mini-scleral exhibited a trace amount of conjunctival blanching 360 degrees only while viewing in peripheral gaze, while slightly more blanching occurred under the same peripheral gazes OS. The lenses were deemed appropriate for dispensing and the patient was trained on insertion and removal, peroxide-based disinfection, and the use of Scleralfil (sterile buffered isotonic saline solution) for cushioning solution. He was instructed to return in one week.

Europa #1 - One Week Follow-Up
After one week, JR was happy with his vision. His visual acuity remained stable at 20/20- OD and 20/25- OS, with an over-refraction of -0.25D over both eyes. Central clearance values at the end of the day were 180µm OD and 170µm OS with a visual estimation of 50µm of limbal clearance 360 degrees OU. Lenses were again rotationally stable and accurately-rotated. Having worn the lenses for 7 hours, there was trace 360 degree impingement of the fine conjunctival vessels within 1mm of the edge of the OD scleral and slightly less-subtle impingement in the OS mini-scleral. The lenses were then removed and JR’s corneas were evaluated with white light and cobalt blue/ sodium fluorescein. His corneas were found to be clear of edematous haze and any epithelial disruption secondary to lens touch OU. JR’s next set of mini-sclerals were ordered with the -0.25 over-refraction in the OS and the scleral’s peripheral edge (PC2/PC3) was lifted by a “half step” OD and a “full step” OS to closer approximate a tangential landing.

*In Visionary Optics nomenclature, PC2/PC3 refers to a 0.25mm change in radius of curvature in a given curve, which will reduce the central sagittal height by roughly 50µm if PC2 and PC3 are being altered. A full step involves a 0.50mm change in radius of curvature, which will net a 100µm drop in sagittal height if PC2 and PC3 are both lifted/flattened.

The patient was re-educated on gentle insertion due to the unusual loss in sagittal height from the first visit. Sagittal heights were not altered despite the possible lens drop with lifted curves as we confirmed that the patient had been inserting the lenses with slightly excessive force. Inserting the lens with excessive force can lead to unnecessary compression of the bulbar conjunctiva and an increase in lens suction, which may result in a false decrease of sagittal height.
Europa #2 - Second Lens Dispense
OD: CLP -7.37D, BC 42D, OAD 15.8mm, CT 0.28mm, Sag 4469µm, spherical back surface
PC1 6.71mm/2.00mm, PC2 9.75mm/0.75mm
PC3 13.75mm/0.5mm, PC4 14.5mm/0.4mm

OS: CLP -11.88D, BC 44D, OAD 15.8mm, CT 0.25mm, Sag 4437µm, 196µm back surface toric
PC1 6.80mm/2.00mm, PC2 10mm/0.75mm
PC3 14mm/0.5mm, PC4 14.5mm/0.4mm

JR returned to the clinic three weeks later and swapped his Europa #1 lenses with Europa #2 lenses. Vision was 20/20-OD and 20/20-OS, with a refraction of -0.25D OD and plano OS. Central clearance values were 150µm OD and 120µm OS, sufficient 360 degree limbal clearance OD/OS, even haptic bearing OD/OS, and proper lens rotation OS. The patient was instructed to return to the clinic in two weeks for a follow-up.

Europa #2 - Two Week Follow-Up
JR returned in two weeks for an end-of-day visit and was extremely satisfied with vision through his mini-sclerals. He found vision to be clear at all distances and was able to wear his lenses throughout the first half of his day without issue. The second half of the day left his eyes feeling a little drier and grittier. Vision remained at 20/20- OD/OS, with -0.25D/plano over-refraction OD/OS. Central clearance was 140µm OD and 120µm OS. All other findings were similar to the previous visit. Again, his corneas were clear of edema and lens touch after being evaluated with white light and later sodium fluorescein.

Despite seeing well through the lenses and a healthy fitting relationship, the mild-moderate amount of dryness was an issue for JR. His lenses would be reordered with the same parameters, but this time Tangible Hydra-PEG would be added to both lenses to enhance comfort. Tangible Hydra-PEG accomplishes this through increasing lens wettability, increasing lubricity, and reducing deposits. Europa #3 would be shipped directly to him and he was instructed to return to the clinic after wearing the new lens for two additional weeks.
Europa #3 – Two Week Follow-Up

JR returned again to the clinic after having worn the new lenses with Tangible Hydra-PEG. The difference in comfort was noticeable and he was now able to wear his lenses comfortably for the entirety of his work day. Vision remained at 20/20- OD/OS, with -0.25D over-refraction OD/OS. Central clearance held stable at 150µm OD and 140µm OS, with adequate limbal clearance. The landing zone was resting evenly 360 degrees and the OS lens rotated well. JR’s lenses were now final and he was instructed to return to the clinic for a six-month follow-up.

Discussion

Keratoconus is a corneal disease which has both genetic and environmental factors. The Collaborative Longitudinal Evaluation of Keratoconus (CLEK) study found that 53% of patients in the study reported a medical history of atopy, with approximately 50% of the patients having reported eye-rubbing. Younger age at keratoconus onset was also linked to worsened severity of eventual visual outcomes. These visual outcomes include irregular astigmatism and scarring of the clear corneal tissue in the advanced stages of the disease.

Due to JR’s experience with blur, glare, and distortion from high ametropia and irregular astigmatism, he went in search of a clearer and more comfortable form of optical correction. A scleral lens represented the best form of correction given JR’s needs. First, scleral lenses completely vault the irregular keratoconic cornea, neutralizing his irregular astigmatism. And unlike corneal GPs, scleral lenses tend to be comfortable because of the distribution of weight across the sclera instead of the highly-innervated cornea. The upper eyelid also interacts less with the lens edge.

In terms of traditional scleral lens fitting, a spherical back-surface diagnostic lens is inserted and the central clearance, limbal clearance, and landing zones are evaluated and modified. Depending on whether the central clearance was appropriate and if the landing zones are tangential, a second trial with a toric back surface or a different sagittal height could be chosen to better fit the eye. There exists the possibility of significant scleral toricity and also scleral asymmetry within the same principal meridian, which can make the initial fitting process
more complex. Recent scleral topography studies showed that 94.3% of scleras at the 16mm chord can demonstrate up to 300µm of toricity.6 With scleral topography such as the sMap3D, scleral data can be accurately and reliably captured up to 22mm to assess the amount of scleral toricity/asymmetry.7,8 In capturing the scleral topography initially, the first ordered lens will more closely approximate the scleral shape. All that is required at the initial fitting is the sodium fluorescein-aided scleral topography scan, the insertion of an sMap3D software algorithm-recommended diagnostic lens of a given sagittal height, and an over-refraction over a known base curve.

Scleral topography with instruments such as the sMap3D, Eaglet Eye, or Pentacam can assist practitioners in achieving a more accurate first lens, but other considerations must still be made. First, scleral topography only measures the static surface of the sclera, it cannot account for how the lens will react with the bulbar conjunctiva. Interactions between the scleral lens and the elasticity of the conjunctiva, the conjunctiva’s ability to deform, or the force of the blink upon the lens surface can only be witnessed post-scleral lens insertion.5,10 A scleral topography-guided scleral lens will still require modifications due to the above. Second, hypoxia must always be minimized with ensuring the highest possible Dk materials are used (ideally >150Dk10), minimizing lens central thickness, and minimizing clearance to below 200µm.11

While the cornea is now protected from the external environment, the rest of the conjunctiva is still subject to environmental conditions such as dust and allergy. Clinicians should keep in mind the importance of managing the eyelids, eyelashes, and reducing friction of the lid wiper across the front surface of the scleral lens.

Conclusion

For patients suffering from keratoconus, scleral lenses represent a corrective option that alleviates their optical blur while offering comfort and stability. Technology such as scleral topography provides the ability to create a more accurately-fitting lens from the start, which benefits both the practitioner and the patient. For the practitioner, gains are made in examination efficiency and a decrease in total chair time. For the patient, they receive a lens that requires relatively little adaptation to wear and most importantly, a return to visual clarity.

References