Contact Lens Update

CLINICAL INSIGHTS BASED IN CURRENT RESEARCH

Reclaiming Vision and Comfort: Overcoming Higher Order Aberrations and Scleral Lens Suction in a Keratoconus Patient

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Background

Even though commonly described as a non-inflammatory, bilateral, and asymmetrical condition with associated thinning and steepening of the cornea, recent studies have reported the presence of inflammatory mediators in Keratoconus (KC).[1-4] This ectasia condition is also characterized by a progressive nature, that leads to irregular astigmatism and a gradual decline in visual acuity. As the cornea becomes increasingly irregular, the optical quality and visual performance can significantly diminish.[1] This decline is often accompanied by an increase in higher-order aberrations (HOAs)[5] and a decrease in contrast sensitivity,[6,7] which further compromise the overall quality of vision.

Scleral lenses are rigid-gas permeable lenses that vault the cornea and rest on the conjunctiva overlying the sclera and provide excellent visual rehabilitation and comfort in eyes with ectatic diseases.[6,8] Due to their excellent stability when worn, these lenses serve as an ideal platform for effectively managing HOAs. This can be achieved by manipulating the front surface eccentricity (FSE) of the lens[7,8] or by offering customized correction for HOAs.[9-11] However, despite their benefits in terms of comfort, it is important to note that scleral lenses settle over time and may occasionally create a seal-off effect, resulting in suction.[12-15]

Case Study

History

28 yo Hispanic male presented with a history of KC, affecting both eyes. The patient had a previous history of corneal lens failure and relevant medical conditions included atopy, allergies, and a past episode of corneal hydrops that resulted in scarring in both eyes. The right eye exhibited more scarring compared to the left eye (Figure 1).

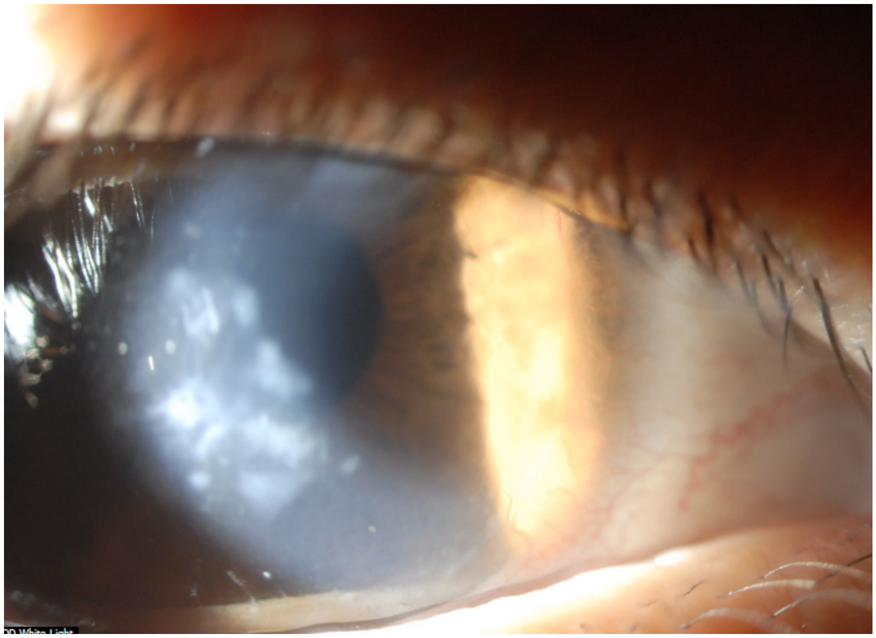

Figure 1: The right eye shows residual corneal scarring following a previous episode of hydrops.

Baseline Clinical Findings

The initial visit took place in 2013, during which the uncorrected visual acuity was measured as 20/400, pin hole (PH) 20/200 in the right eye, and 20/200, PH with no improvement (NI) in the left eye. In addition to the patient's subjective response to scleral lenses, the consultation process included the objective assessment of various parameters related to fitting and visual outcomes. The fitting parameters included the use of quadrant-specific (QS) designs to accommodate the asymmetrical contour of scleral shape and anatomy, appropriate combinations of sagittal height and base curve to achieve adequate corneal/limbal clearance, and optimal optic parameters for attaining best corrected visual acuity (BCVA). Since the qualitative aspects of vision in KC patients often differ from the quantitative aspects of visual correction, even with rigid lens optics, the consultation also involved testing different FSEs to determine the most favorable visual outcome in terms of both qualitative and quantitative aspects. Baseline corneal topography measurement using the Medmont instrument (Nunawading, Australia) revealed steep keratometry (K) values of 65D in the right eye and 68D in the left eye (Figure 2).

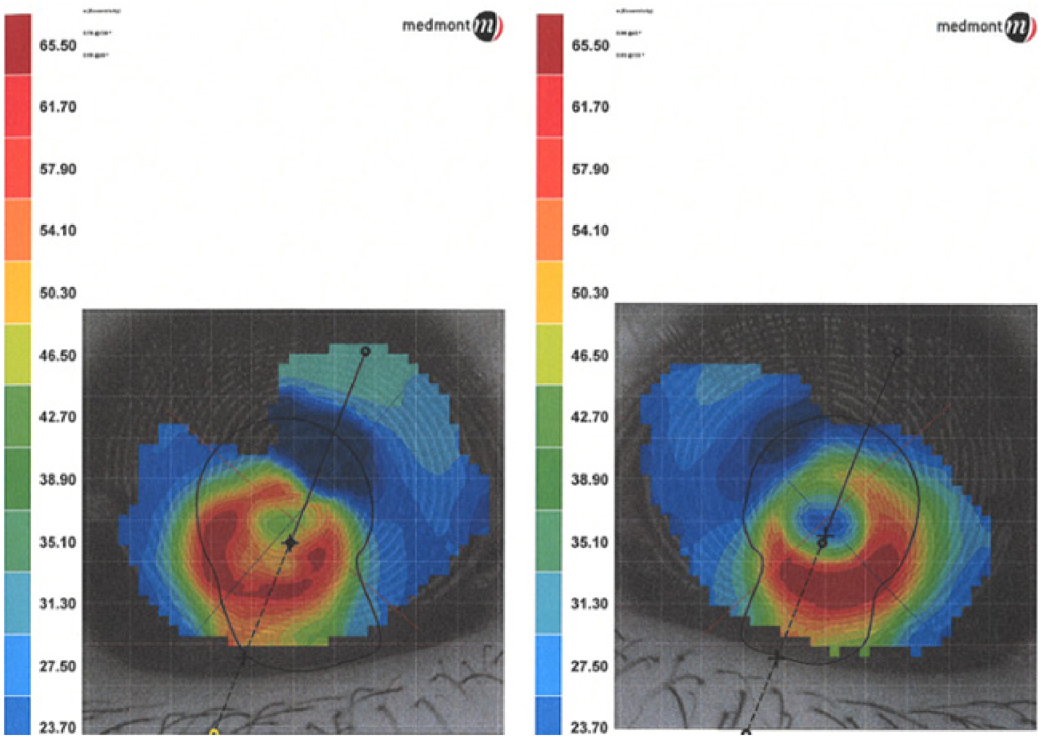

Figure 2. Baseline corneal topography for right and left eyes.

Scleral Lens Fitting Strategy

To ensure better weight distribution of the lens over the conjunctival tissue, the patient was fitted with 18.5mm lenses, which cover a larger surface area. After retesting various FSE options, it was determined that FSE1 provided the most favorable subjective and objective visual response. Consequently, BCVA significantly improved to 20/30^{+2} PH NI in the right eye and 20/20 in the left eye. Based on these outcomes, the decision was made to order the final lenses with FSE1 and the following parameters:

OD: 3170um SAG (12mm chord)/8.50 BC/+1.25 SPH/FSE1/18.5mm DIAM/0.3mm CT/QS HAPTICS
OS: 3260um SAG (12mm chord)/8.50 BC/+1.75 SPH/FSE1/18.5mm DIAM/0.3mm CT/QS HAPTICS

Follow-ups

The patient expressed great satisfaction with the improved vision, as his BCVA remained stable at 20/30^{+2} with no improvement (PH NI) in the right eye and 20/20 in the left eye. The patient also reported excellent comfort, tolerance, and an average wear time of approximately 12 hours per day. Subsequent follow-up evaluations conducted at two- and three-month intervals post-fitting demonstrated satisfactory physiological function in both eyes.

Over the course of the next five years, the patient's progress remained positive. Annual evaluations consistently revealed stable visual correction, comfort, and physiologic function in both eyes. However, in 2018 the patient presented to the clinic with a chief complaint of decreased visual acuity in the right eye.

Assessments & Plan

Lens Fit Assessment & Plan

Signs of KC progression were observed in the right eye, with central corneal touch and areas of mid-haptic compression, potentially due to lens settling over time (Figure 3). The patient also reported increased difficulties in lens removal at the end of the day and acknowledged the presence of increased hyperemia after removing the lens. The patient's BCVA in the right eye also declined to 20/60^{-2}, PH 20/30.

Although the patient was advised to undergo new corneal topographies, he deferred diagnostic testing at that time. The findings were discussed with the patient, and it was mutually agreed to proceed with the fitting process based on clinical observations made during the slit-lamp examination. Accordingly, the patient was refitted by increasing the central sagittal height and increasing the lens diameter to 19.5 mm. These modifications aimed to compensate for the increased sagittal height and redistribute the lens weight over a larger surface area.

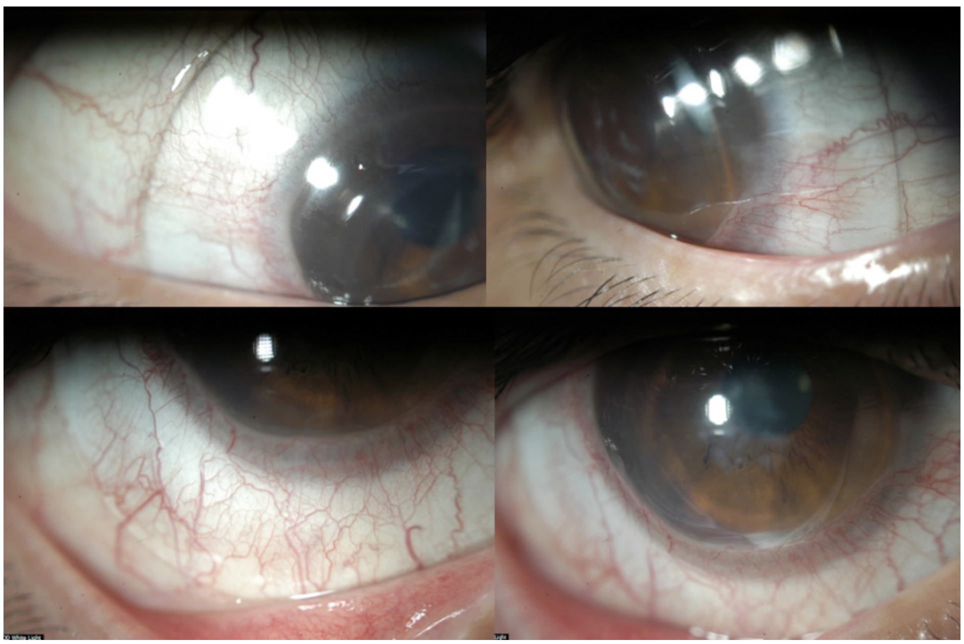

Figure 3: An 18.5 mm quadrant-specific lens with signs of mid-haptic compression and hyperemia as presented to clinic in 2018 – corneal apical touch was also noted; right eye.

Visual Assessment & Plan

Despite efforts to optimize the prescription in the right eye using sphere and sphero-cylindrical over-refractions, the best visual outcome achieved with the current lens optics (FSE1) was 20/40^{-2} (slow and with a push). Additionally, the patient reported a decline in visual quality, particularly mentioning an increase in ghosting, which was not previously noticed to this extent with scleral lens wear.

To gain a better understanding of the underlying issue, aberrometry measurements were obtained while the patient was wearing the scleral lens (iTrace, Tracey Technologies, Houston, TX). Figure 4 shows the pattern of HOAs observed in the right eye revealing significant amounts of residual coma, spherical aberration, and trefoil.

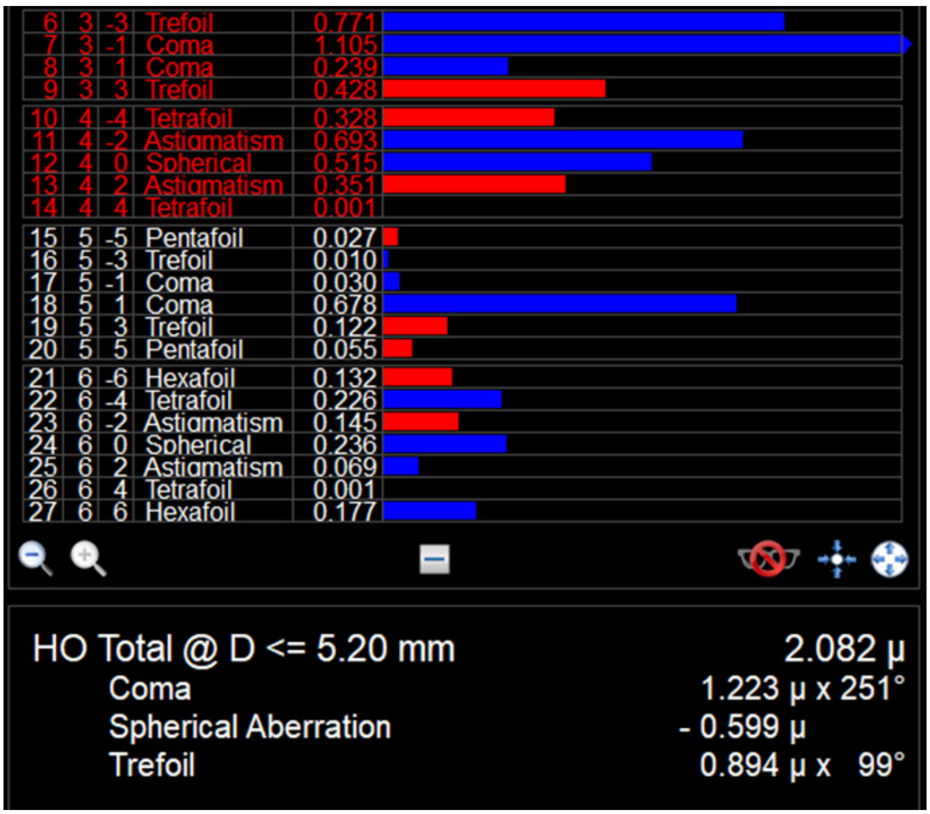

Figure 4: Higher order aberration pattern observed in the right eye while wearing the current scleral lens with the existing built-in front surface eccentricity (FSE1) correction, as well as after correcting for low order aberrations.

After discussing the findings with the patient, it was agreed to explore alternative FSE options to correct and minimize the impact of HOAs in the right eye, before considering a more customized approach. Consequently, a higher FSE value, FSE2, was attempted.

Utilizing the new optical system, notable objective improvements were observed in the HOAs. Figure 5 shows the objective reduction in coma (46.77% decrease), spherical aberration (85.14% decrease), trefoil (22.82% decrease), and the total HOA amount (39.39% decrease). Additionally, the patient's BCVA in the right eye was successfully restored to the 20/30 range, which was initially achieved with the scleral lens.

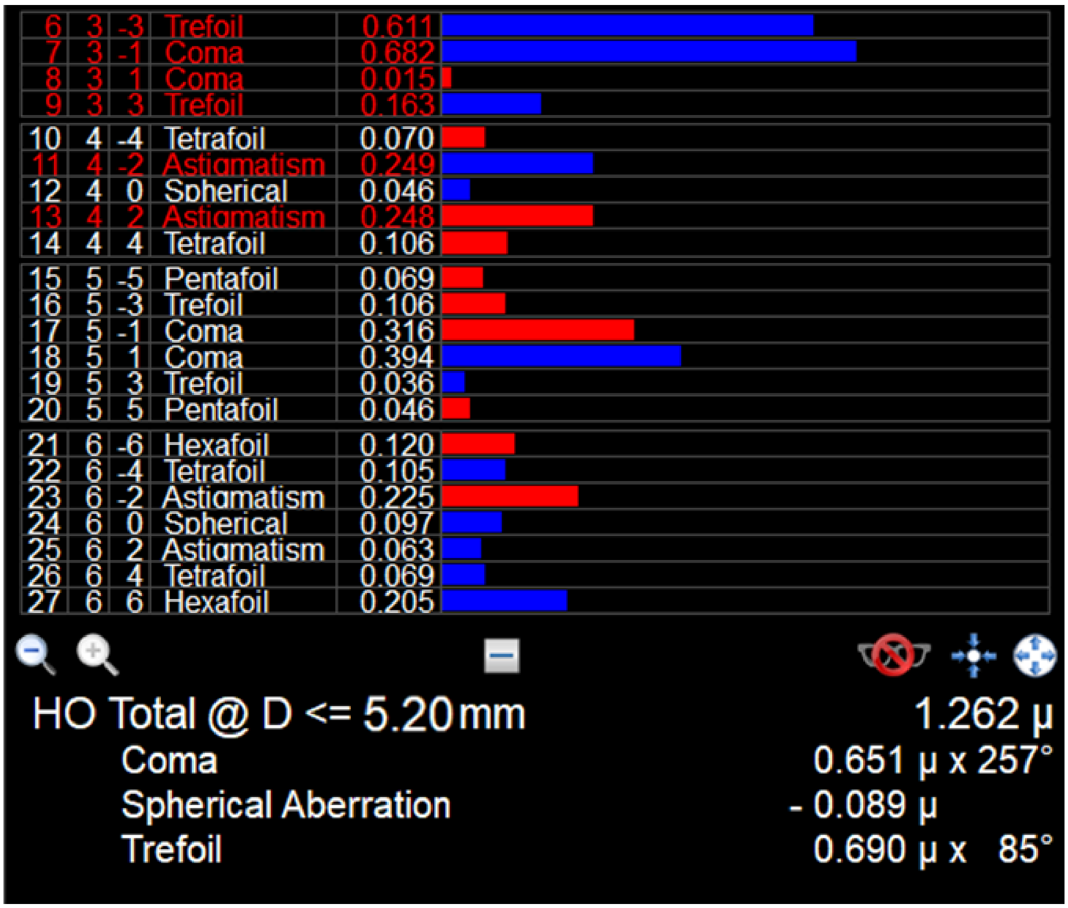

Figure 5: Higher order aberration pattern observed in the right eye while wearing the new scleral lens with increased front surface eccentricity (FSE2).

Subjective reports indicated reduced ghosting and an overall improvement in visual quality. The patient was provided with the new 19.5 mm lens for the right eye, was instructed to wear the lens and return for a follow-up appointment after one month.

One-month Follow-up

During the one-month follow-up, the patient expressed satisfaction with the BCVA in the right eye, which remained in the 20/30 range. However, despite showing fewer signs of mid-haptic compression, the patient reported experiencing a dull ache at the end of the day and rebound hyperemia after lens removal, despite an overall improvement in comfort.

New Assessment & Plan

Since the fitting relationship along the conjunctiva appeared to be adequate, with no signs of impingement or staining after lens removal, the possibility of incorporating back-surface channels (Figure 6) and haptic fenestrations (Figure 7) was discussed with the patient. These modifications aimed to reduce suction, improve comfort, and increase wear time. The patient agreed to proceed with these fitting adjustments. The final scleral lens parameters for the right eye were as follow:

OD: SAG 3705um (12mm chord)/6.10 BC/-10-4.00x050/FSE2/19.5mm DIAM/0.3mm CT/QS HAPTICS

Follow-up Outcomes

Following the addition of these customization features, the patient reported significant improvement in comfort, a decrease in rebound hyperemia after lens removal, ease of lens removal at the end of the day, and the ability to comfortably wear the right lens for approximately 12 hours per day. Objectively, the eye appeared whiter, with good lens alignment (Figure 7). The BCVA in the right eye appeared stable in the 20/30 range.

In the left eye, the scleral lens exhibited an optimal vault and alignment, and the BCVA remained consistently at 20/20.

Figure 6: Back-surface channels added to a 19.5mm, quadrant-specific lens, to reduce suction.

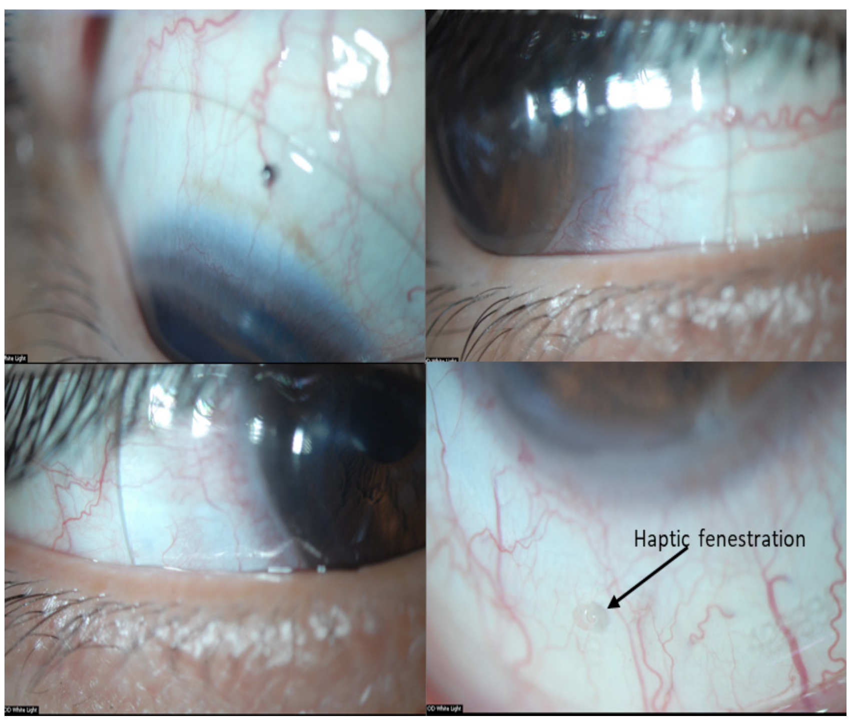

Figure 7: Final fit of a 19.5mm, quadrant-specific design with back-surface channels and haptic fenestrations to reduce suction; right eye.

Discussion

Scleral lenses have proven to be an effective option for visual rehabilitation in KC patients.[6-8,16] These lenses offer both visual improvement and enhanced comfort by vaulting the sensitive cornea and distributing their weight onto the conjunctival tissue.[6] However, fitting KC eyes require special considerations due to the varying steepness and elevations of the cornea. The total sagittal height of scleral lenses in eyes with KC tends to be high, making lens diameter choices crucial.

It has been shown that increased sagittal height in scleral lenses can result in higher pressure on the haptic, leading to compression in the underlying conjunctiva.[17] This compression can be mitigated by using larger diameter lenses, which offer wider weight distribution and tend to settle less over time compared to smaller diameter scleral lenses.[13] These factors become particularly important when fitting moderate to severe KC. In the case described here, which is classified as a severe KC (>52D) according to the CLEK classification,[18] an initial lens diameter of 18.5mm was chosen. While this diameter provided satisfactory results for several years, as the ectasia progressed, the patient experienced haptic compression, lens intolerance, rebound hyperemia, and difficulties with lens removal at the end of the day due to increased suction, leading to patient dissatisfaction.

To address these issues, a troubleshooting strategy was implemented by increasing the scleral lens diameter to redistribute the weight over the conjunctiva. Typically, increasing the lens diameter, up to 23-24mm, can often resolve the problem. However, if signs of compression persist, additional customization features that decrease suction, such as back surface channels and haptic fenestrations, should be considered. In this particular case, the combined approach of increasing the lens diameter and incorporating these customization features was the key to achieving comfortable lens wear.

In advanced KC cases, higher amounts of HOAs are often observed.[7,8] Scleral lenses offer a suitable platform for custom HOAs correction, as lens stability is essential[9-11] and quadrant-specific customization is possible. However, this approach is more complex and expensive. An alternative method to mitigate the impact of HOAs on the visual quality in ectatic conditions is to modify the FSE of scleral lenses.[7,8] In the present case, modifications in the FSE resulted in a restoration of vision and a significant reduction in HOAs. Balakrishnan et. al (2022) reported similar findings, demonstrating a notable reduction in HOA - root mean square (RMS), trefoil, spherical aberration, and coma with scleral lenses featuring FSE.[8] This is particularly important for patients who cannot afford the more expensive custom HOAs correction or for practitioners who lack access to aberrometers in their clinics.

In conclusion, successful management of KC patients involves addressing both the mechanical and optical aspects of the fit. Ensuring a proper mechanical fit promotes physiological function and involves troubleshooting strategies to achieve homogenous lens weight distribution and minimize suction. Additionally, customized optics play a crucial role in controlling HOAs and optimizing visual quality. By combining these considerations, practitioners can provide effective treatment for KC patients.

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