Steepening the Curve: Orthokeratology for the Hyperopic Cornea

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PURPOSE

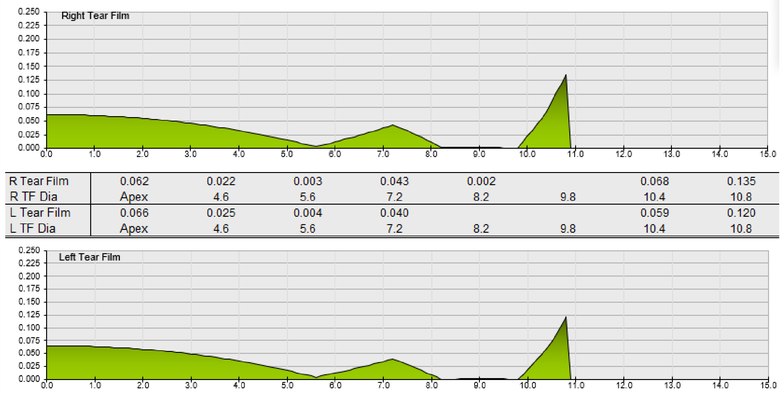
Empirical fitting of specialty contact lenses has become increasingly popular, replacing the need of multiple trial lens from a set to provide a more streamlined fit for patients. Corneal topographies can be sent to labs which can design lenses empirically and reduce the need for remakes. There are even software solutions to lens design that incorporate topographic data to model a corneal surface and allow the fitter and lab to predict how a custom lens will fit on the eye. Hyperopic orthokeratology can make use of this new method as many fitting sets will not have hyperopic options. As opposed to traditional orthokeratology which flattens the cornea, hyperopic correction involves steeping the cornea. This central steeping provides the plus power correction to leave the patient emmetropic and go throughout the day without any form of correction.

LENS FITTING

The Ortho-K lens was designed using the Orthotool software which requires the patient's keratometry values, corneal eccentricity, HVID, and patient's spectacle Rx. This information is provided to the software and a lens is designed from this data.
Based on the patient's HVID the lens size was designed to be 95% equivalent. The base curve was chosen to be 3D steeper than flat K of the cornea to provide the hyperopic correction. The design used two flatter curves in the mid-periphery, separated by a steeper area between, to align with the cornea and allow fluid forces to promote corneal health and reshaping.

Measurements Obtained at First Visit		
	OD	**OS**
Flat Ks	41.00	41.00
Steep Ks	42.00	42.00
Spectacle Rx	+1.25-0.25x180	+1.75-0.50x180
Aided VA	20/20	20/20
HVID	11.5	11.5
Flat Eccentricity	0.40	0.55

Table 1: This table shows the values obtained at the initial visit. They were used to calculate lens parameters.



R Tear Film	0.062	0.022	0.003	0.043	0.002		0.068	0.135
R TF Dia	Apex	4.6	5.6	7.2	8.2	9.8	10.4	10.8
L Tear Film	0.066	0.025	0.004	0.040			0.059	0.120
L TF Dia	Apex	4.6	5.6	7.2	8.2	9.8	10.4	10.8

Figure 1: The graph generated in the OrthoTool program shows the approximate clearance between the lens and cornea in various zones. For this hyperopic OK design, approximately 60 microns of central clearance was desired in the treatment zone. Alignment is achieved 4.5mm from the center (at 9mm chord). There are two curves between these zones to generate additional fluid forces.

	7.40	10.8	0.18	7.50	9.30	7.50	8.40	11.00	12.72
			PC Width	0.50	0.80	0.50	0.80	0.30	0.20
	Base Eco								
			OD Notes:						
	Base	Diameter	CT	IC1	IC1a	IC1b	IC2	IC3	IC4
	7.40	10.8	0.18	7.50	9.30	7.60	8.60	11.00	12.72
			PC Width	0.50	0.80	0.50	0.80	0.30	0.20

Table 2: This table shows parameters of the lens ordered for the patient (OD top and OS bottom).

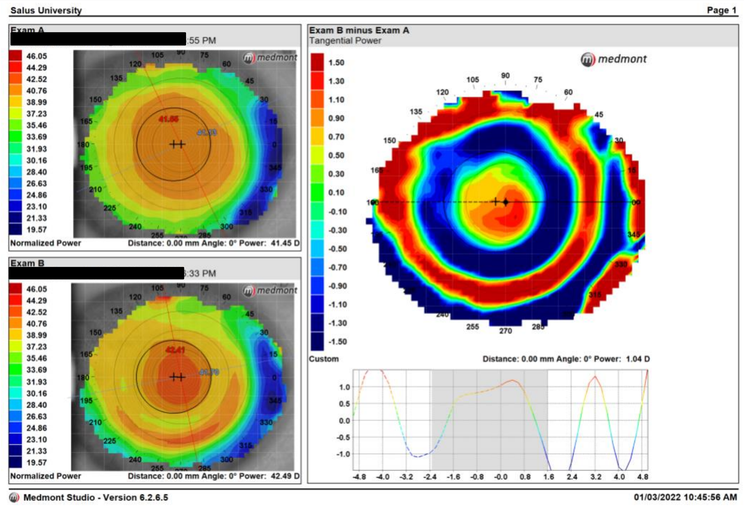


Figure 2: This figure shows the tangential map (OD) which reveals not only a well centered treatment zone, but one of a sufficient size as well. The areas demonstrating steepening and flattening can be reflected on the fluorescein pattern. **The patient's VAs were 20/20.**

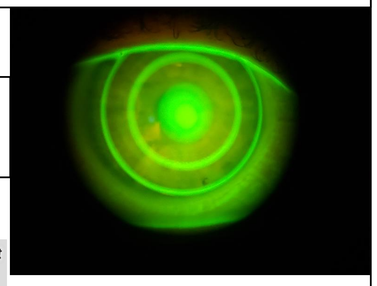


Figure 3 (right): This figure shows the Ortho-K lens that was fit on the patient's eyes stained with fluorescein, OD. The lens fittings revealed well-centered reverse bull's eye patterns with pooling centrally and bearing along the mid-periphery. This is the opposite of what is seen in traditional myopic Ortho-K.

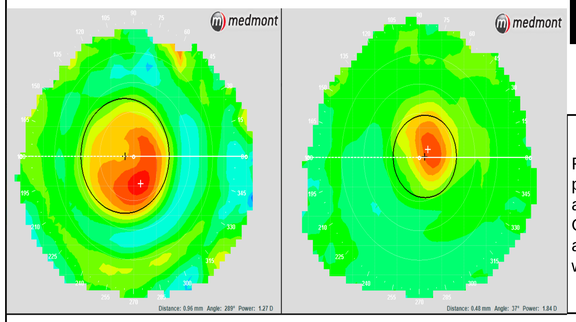


Figure 4 (left): This figure shows the axial power map demonstrating the position and amount of hyperopic correction to OD (left) and OS (right). The axial map shows the relative amount of correction. The patient's VAs were 20/20 OD and 20/20 OS.

RESULTS

The OS base curve was steepened an additional 0.50 to provide best visual correction and the patient wore the lens for two weeks to achieve full correction. After full treatment from the OK lenses, the patient was able to achieve around +1.00 D of correction in the right eye and around +1.75 D in the left eye . This allowed the patient to go throughout her day without the need for spectacle or contact lens correction. The patient reported no adverse side effects from her use with the Ortho-K lenses.

DISCUSSION

Corneal refractive surgery is an alternative to lens wear, however it presents a similar problem to OK. Steepening the cornea is a much more difficult and complicated task with hyperopic corneal refractive surgery as compared to the flattening in myopic corneal refractive surgeries. Frings et al. reported less accurate predictability, under-correction, and that many hyperopic cases will require a retreatment to achieve ideal outcomes.

One area of lens design that can be changed to improve visual results is the central steeping zone. Studies examined how changes in the treatment zone (TZ), a combination of the central steeping zone (CSZ) and the surrounding annular flattened zone (AFZ), resulted in decreased visual acuity. A reduction in CSZ diameter resulted in an increase in AFZ and a resulting decrease in visual acuity. For hyperopic LASIK an increase in the central optic zone, which is analogous to the CSZ of a hyperopic OK lens, results in an increase in visual acuity. It is thus hypothesized that increasing the CSZ of a hyperopic OK may result in better and longer lasting visual acuity, but further testing is warranted.

Monovision is a longstanding practice used with contact lenses, refractive surgeries, and intraocular lens implants where the patient has one eye corrected for distance and one eye for near. It thus stands to reason that in an emmetropic presbyope, hyperopic Ortho-K could provide a simulated monovision type of correction if worn in one eye. Gifford and Swarbrick had patients who required no spectacle correction for distance but required spectacle correction for near wear an Ortho-K designed to induce +2.00 diopters of correction in their non-dominant eye. The results of this study showed that after seven nights of lens wear, binocular distance visual acuity was no different from baseline finding. After day seven binocular near acuity was measured at Jaeger 3.2 with an end of day (eight hours) regression to Jaeger 3.9 (normal newspaper print is around Jaeger 5 or the equivalent of 8 point font).

CONCLUSION

Hyperopic OK provides an exciting new avenue for patients who wish to be free from spectacle or daytime contact lens correction. These lenses also provide a safer alternative to refractive surgery and is completely reversible should the patient be unhappy with their vision. With continued advances in corneal topographic data collection and newer lens designs an increase in hyperopic correction can be expected. Hyperopic correction may also provide new options for presbyopic OK correction. While myopia control with OK lenses should continue to be improved, the hyperopic option should not be ignored.

Acknowledgments/References

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