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RESHAPING TORIC CORNEAS WITH ORTHOKERATOLOGY: A CASE STUDY

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ABSTRACT

The use of specially designed reverse geometry lenses, known as orthokeratology (ortho-K) lenses, has gained popularity recently. There are various names to this technique: corneal reshaping therapy, corneal refractive therapy, overnight corneal reshaping, corneal molding system, Vision Shaping Treatment, and many more. The advantage of applying this technique is that it results in a temporary reduction of the refractive error by flattening the central cornea with overnight wear of the specially designed lens. Ortho-K lenses are also widely used as a modality for slowing myopia progression in children. With advances in technology and lens design, high refractive errors and astigmatism are now possible to correct. This case presentation summarizes a successful fitting of toric ortho-K lenses to reshape a toric cornea with high myopia and astigmatism.

Keywords: myopia; myopia progression; ortho-K, reverse geometry lenses; toric

INTRODUCTION

The prevalence of myopia varies based on the geographic region, ethnic group, and family history, with a range of 50–90% in some Asian populations.[1,2] There are various options available to help patients with myopia and astigmatism to see clearly, which include spectacle lenses, toric soft contact lenses, corneal and scleral rigid gas-permeable lenses, hybrid, and refractive surgery, all of which bring light rays back into focus on the retina. Orthokeratology (ortho-K) is a technique that allows these patients to achieve clear vision without the use of spectacles or contact lens wear during the waking hours. This technique was first described in the 1940s but has now gained clinical acceptance due to the advancement of high oxygen-permeable materials and reverse geometry designs. The first evaluation of ortho-K lenses was conducted in the 1970s by Kerns, who compared conventional design

flat-fitting rigid lenses with orthokeratological technique.[3] The term "Accelerated OK" refers to the new design due to its scope of rapid correction approved by the United States Food and Drug Administration in the year 2002, which allows myopic correction for up to 6 diopter.[4]

CASE REPORT

Visit 1: Initial visit

A 25-year-old Asian female presented to the contact lens clinic with interest to try toric ortho-K contact lenses. She reported that she had tried spherical ortho-K lenses a month ago, but the outcome was unfavorable. The practitioner had advised on a toric ortho-K lens fitting a month later. She is a spectacle wearer since the age of 12. She is an occasional daily disposable soft toric contact lens wearer mainly for her sporting activity (badminton). Her ocular history is high myopia with astigmatism. Her ocular health and systemic health were unremarkable. She routinely went to the optician for an annual eye examination and had new glasses made. She reports that her refraction has been stable for 5–6 years now. She had no known drug allergies. She wanted to try ortho-K lenses as she wanted to be free from spectacles. She was denied laser refractive surgery 2 years ago by the ophthalmologist due to high refractive error.

Upon examination, her corrected distance visual acuity with habitual correction was 6/6 in the oculus dexter (OD) and oculus sinister (OS) monocularly, while her uncorrected distance visual acuity was 2/60, improving to 6/9 with a pinhole on OD and 2/36 improving to 6/9 with pinhole. Confrontation visual field was performed, and the results revealed full in both eyes, and extraocular motility was SAFE without pain or double vision. Pupils were equal, round, and reactive to light with no signs of relative afferent pupillary defect. Intraocular pressure was measured using Icare tonometry, which was recorded to be 17 mmHg on OD and 18 mmHg on OS at 9:28 A.M. Manifest refraction was −7.25 −1.50 × 180 OD and −5.75 −2.25 × 170 OS with best-corrected distance visual acuity of 6/6 OD and 6/6 OS. Manifest refraction matched the focimetry of her habitual glasses. Slit-lamp biomicroscopy revealed the ocular adnexa's regular appearance, lids, lashes, conjunctiva, and cornea on both eyes. No significant corneal staining was detected with 1 mg fluorescein sodium LP moisten with normal saline. The tear breakup time was 9 seconds OD and 8 seconds OS.

Corneal topography examination was performed using Tomey TMS-5 Scheimpflug and Topographer (Tomey Co., Ltd., Nagoya, Japan). The results of the baseline topography values are shown in Figure 1 (A,B).

The patient's goal was to be spectacle free; hence, ortho-K lenses were suggested. A diagnostic fitting for the toric ortho-K lens was done. Ocuviq dK-4 toric fitting guide was used to calculate the parameters of the initial lens. The initial diagnostic lenses were then inserted, and fitting was assessed. The lenses were centered in both eyes with a "bull's eye" pattern on OD, whereas a slight central pooling was observed on OS. The lens for OS was flattened by 0.50 D, which gave a "bull's eye" pattern.

Additionally, an acceptable deviation of 20° counterclockwise was observed. There was adequate edge lift and tear exchange, and lenses had no rotation upon blinking. The lenses were ordered based on the parameters shown in Table 1. The patient was discharged and was advised on the lens delivery once the lenses arrived.

Visit 2: Lens dispensing

The patient came to the clinic for her ortho-K contact lens dispense. Lenses were presoaked overnight with Boston Simplus™ Multi-Action solution before dispensing. The patient was taught about lens insertion, removal, and handling. The fitting assessment was performed with the lenses, revealing a distinct bull's eye pattern on both eyes, as shown in Figure 2 (A,B). The patient was educated regarding the use of lens care systems, including normal saline for rinsing the lenses and artificial tears (Tears Naturale™ Free PF, Alcon) as a comfort eye drop to be placed on the lens before insertion. Distance visual acuity with lenses on was 6/6 on OD and OS.

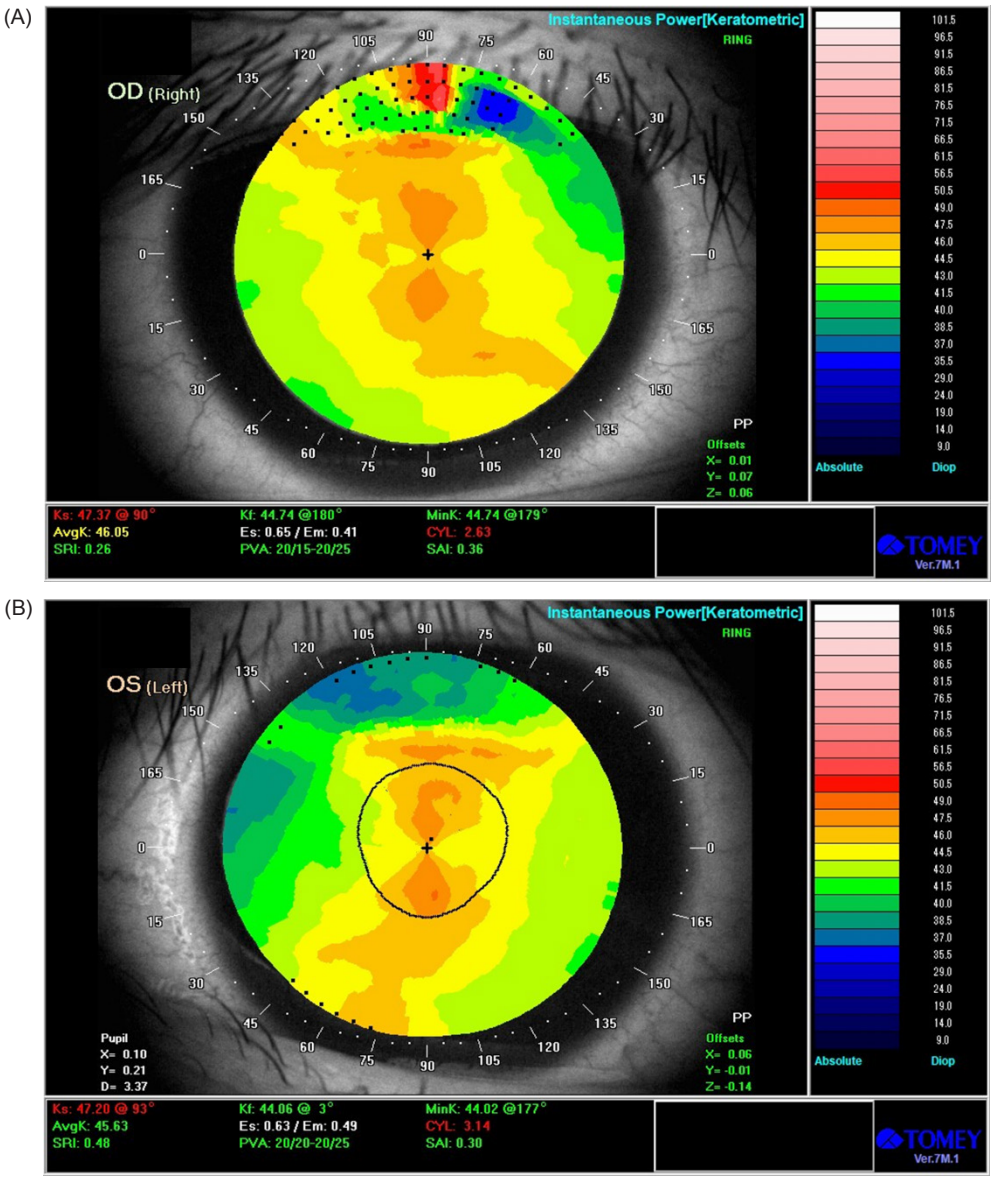

FIGURE 1. Corneal topography measured using Tomey TMS-5 Scheimpflug and Topographer (Tomey Co., Ltd., Nagoya, Japan). (A) shows the instantaneous map of the right eye, and (B) shows the instantaneous map of the left eye. A higher amount of corneal astigmatism was observed in the left eye compared to the right eye.

The lens fitting was satisfactory, and the lenses were dispensed after the patient signed informed consent and understood appropriate care and handling with contact lenses. Her subsequent follow-up was scheduled for the following morning.

Visit 3: Follow up # 1

The patient returned to the clinic the following day for the first overnight follow-up. She had removed the lenses about an hour before her visit. The patient reported comfortable wear throughout

TABLE 1 Parameters of the Final Lens Order for Ocuviq dK-4 Toric.

Parameter	OD	OS
Material	Boston XO (Hexafocon A)	
Asymmetricity or cylinder change	A2/−1.50	A2/−2.25
Ref K	45.50 D	45.00
B.C or diameter	9.19/10.60	8.95/10.60
Target	−7.00 D	−5.75 D
EV value	Standard	Standard
Optic zone diameter	6 mm	6 mm
Tint	Green	Violet

BC, base curve; EV, exposure value; OD, oculus dexter; OS, oculus sinister.

the night for about 8 hours of wear. She also mentioned that the lenses were centered and easy to remove in the morning. Uncorrected distance visual acuity was 5/60 on OD and 6/60 on OS. The manifest refraction was −5.00 −0.75 × 180 OD and −4.25 −1.50 × 170 OS with best-corrected distance visual acuity of 6/6 OS and 6/6 OS. With a spherical equivalent refraction of −5.50 D on OD and −5.25 D on OS, the distance visual acuity was $6/9^{+3}$ OS and $6/9^{+2}$ OS.

Corneal topography by TMS-5 showed some flattening of the central cornea with good centration. Slit-lamp examination revealed no abnormal findings on the ocular adnexa, lids, lashes, puncta, cornea, and conjunctiva. The corneas were clear and intact, with no staining observed after the instillation of sodium fluorescein.

A soft daily disposable contact lens with a power of −5.25 D in the right eye and −5.00 D in the left eye was dispensed for Day 0. The patient was dispensed the same brand with reducing power in steps of 0.50 D for the following days, as shown in Table 2. The patient was scheduled to visit the clinic 9 days later to evaluate the progress of ortho-K lens. She was also advised to return to the clinic sooner in case of any new symptoms, including redness, sticky discharge, or uncorrectable vision with soft contact lenses.

(A)

(B)

FIGURE 2. Anterior segment photograph of both the eyes showing "bulls' eye" pattern with about 4–5 mm central treatment zone with adequate edge lift at 10X magnification using a Topcon Slit lamp with a Wratten filter #12.

Visit 4: Follow up # 2

The patient reported to the clinic 9 days later. The practitioner followed up with the patient frequently via text messages and ensured that he or she enjoyed good vision with the daily disposable soft lenses prescribed as per Table 2, and that there were no ocular changes such as redness or discharge. The patient came wearing the last pair of the 1-day soft contact lenses prescribed. Distance visual acuity with the soft lenses was 6/6 OD and $6/6^{-3}$ OS. Soft contact lenses were removed. Uncorrected distance visual acuity was $6/12^{-4}$ on OD and 6/12 on OS.

TABLE 2 Powers of the Soft Daily Disposable Lenses Prescribed to the Patient.

OD	Day	OS
−5.25 D	0	−5.00 D
−4.75 D	1	−4.50 D
−4.25 D	2	−4.00 D
−3.75 D	3	−3.50 D
−3.25 D	4	−3.00 D
−2.75 D	5	−2.50 D
−2.25 D	6	−2.00 D
−1.75 D	7	−1.50 D
−1.25 D	8	−1.00 D
−0.75 D	9	−0.50 D

OD, oculus dexter; OS, oculus sinister.

The manifest refraction was −1.00 −0.25 × 180 OD and −0.75 −0.50 × 180 OS with best-corrected distance visual acuity as 6/6 OD and 6/6 OS.

Corneal topography examination using Tomey TMS-5 showed a fair amount of central corneal flattening with good centration in both eyes (right eye better than the left eye). The results of the topography map are shown in Figure 3 (A,B). A slight inferior temporal displacement was observed on both eyes, but no lens modifications were done because the vision was not affected. Slit-lamp examination was within normal limits. The corneas were clear and intact, with no staining observed when tears were stained with 1 mg fluorescein sodium LP moistened with normal saline.

On subsequent follow-ups, patient reported enjoying her unaided vision throughout the day for almost 10–12 hours. Patient was followed up every 3 months for an aftercare assessment.

DISCUSSION

Myopic refraction above 5.00 D is "high myopia" and has a potential risk of developing sight-threatening eye diseases.[5,6] The retinal image has to be brought to focus on the retina with corrective lenses such as spectacles, contact lenses, or refractive procedures.

Orthokeratology gas-permeable lenses (ortho-K) temporarily reshape the cornea without any surgical intervention to decrease myopic power and enhance uncorrected vision.[7] A toric ortho-K lens differs from a spherical ortho-K lens in terms of the design itself, as the optical zone consists of the spherical design, whereas the reverse or alignment zone consists of the toric design. The toric ortho-K lens's function is to provide a better fit between the lens and the cornea in the mid-peripheral zone which promotes stability and centration.[8] It is thought that patients with moderate to high astigmatism are not suitable for the spherical ortho-K lens due to the possibility of significant lens decentration and reduction in quality of vision. It is known that the higher the amount of corneal astigmatism, the greater is the lens decentration.[9]

A study to investigate the effectiveness of toric ortho-K lenses in the correction of myopia and astigmatism in pediatric populations with moderate to high astigmatism concluded that toric ortho-K lenses had a successful lens fit of 95%.[10] It was also suggested that the toric ortho-K lens option should be considered for patients who have corneal astigmatism exceeding 1.50 D.[10–13] While selecting toric ortho-K subjects, evaluation of the magnitude and type of astigmatism is essential as there are toric ortho-K designs that have full and peripheral toricity.[14]

The patient was fitted with Ocuviq dK-4 toric lenses, which work on the corneal power difference (CPD) at 7 mm zone. They have five asymmetric designs to choose from based on the calculation of CPD. The details of the lens designs are shown in Table 3.

A tangential (instantaneous) map is used in ortho-K as it provides a better representation of the cornea's shape as they are not based on an optic axis.[15] The corneal topographer must be repeatably accurate when measuring the axial and tangential (instantaneous) maps to help practitioners understand the corneal profile changes at each aftercare visits.[16,17] The CPD was calculated for the patient by manually obtaining the corneal diopter

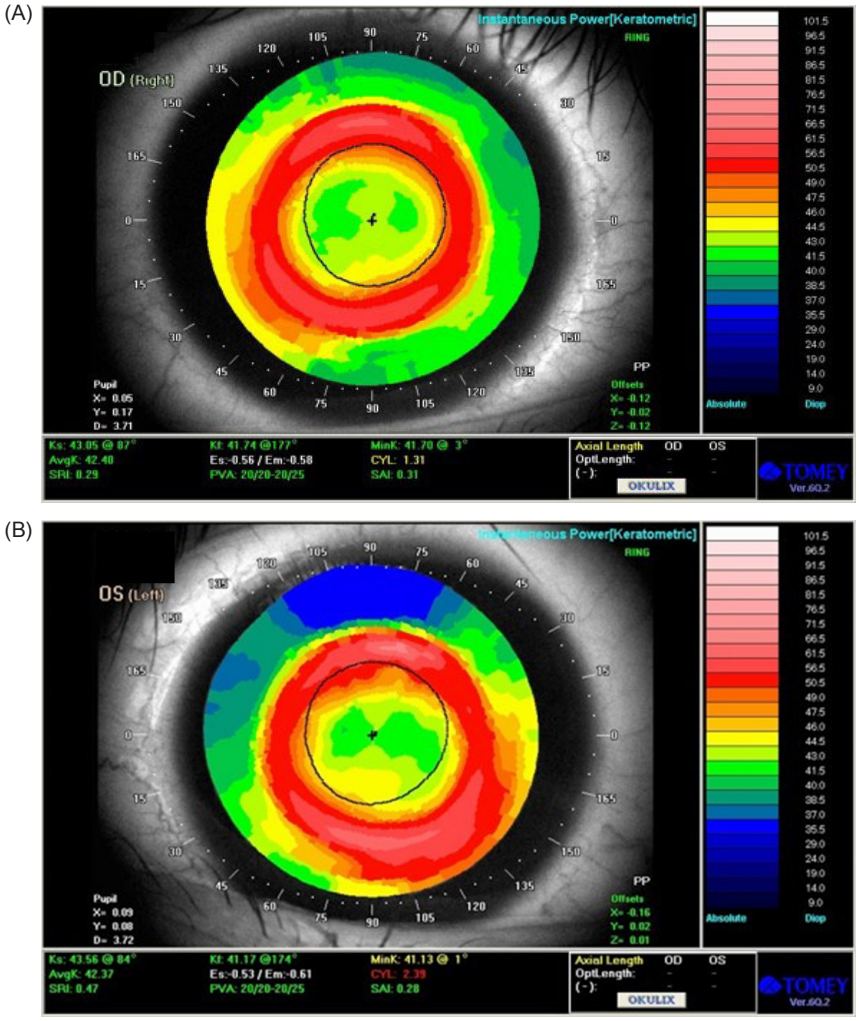

FIGURE 3. Corneal topography measured using Tomey TMS-5. (A) shows the instantaneous map of the right eye, and (B) shows the instantaneous map of the left eye after 9 days of toric ortho-K lens wear.

values 3.5 mm in all directions from the center. The calculations for OS are shown in Table 4. Tomey TMS-5 does not have relevant zone analysis as in the Medmont E300 topographer.[17] Because the calculated power difference was 2.45 D, the asymmetricity design of A2 (Table 4) was chosen for this patient.

Studies by Chen et al. (2013), Goggin (2008), and Liong et al. (2015) have reported that the most significant reduction occurs after the first overnight wear (~60%) for myopia <5.00 D which then

TABLE 3 Asymmetricity of the Lens Based on the Corneal Power Difference at 7 mm Zone.

Lens design	CPD at 7 mm zone
Spherical dK lenses	≤ 1.50 D
A1 design	< 2.00 D
A2 design	< 2.50 D
A3 design	< 3.00 D
A4 design	< 3.50 D
A5 design	< 3.00 D

CPD, corneal power difference.

TABLE 4 Corneal Power Difference at 3.5 mm from the Center to Different Positions for OS.

Position	OS	Average CPD of the meridian	CPD
Superior	39.60 D	(39.60 + 44.90)/2 = 42.25 D	(42.25–39.80) = 2.45 D
Inferior	44.90 D		
Nasal	38.40 D	(38.40 + 41.20)/2 = 39.80 D	
Temporal	41.20 D		

CPD, corneal power difference; OS, oculus sinister.

slowly stabilizes for the following week.[11,18,19] A reduction of 2.25 D OD and 1.50 OS on the spherical component accounts for ~30% reduction in this patient's prescription. Corneal astigmatism was also reduced by almost 40–50% in both eyes. The rate of reduction was slower, probably because of the high amount of myopia and corneal astigmatism. Alharbi and Swarbrick (2003) have also stated that an individual's refractive error would change and stabilize after continuous wear of the ortho-K lens for 7–10 nights,[20] which was also noted in this patient.

Lens centration plays an essential role in the effect of ortho-K lenses. Studies by Cho et al. (2003) and Charm (2017) reported that lens decentration and corneal staining tend to occur more frequently when the target power is more than 5.00 D.[21,22] Because the patient was a high myope, this could be a possible reason why there was inferior temporal decentration, as mentioned earlier. The patient did not have any vision-related complaints; hence, no lens parameters were changed. Toric corneas can be reshaped successfully, as presented in a case report.[23] Software-based system or empirically fitting philosophies help reduce chair time.[11,19] However, the lenses used for this patient are based on diagnostic fitting philosophy. Initial calculations to determine the appropriate design and lens parameters must be performed by the practitioner before the fitting assessment. With toric ortho-K lenses, high myopia and astigmatism are now correctable, and there may not be the need to partially correct high myopes as done in the past.[24]

CONCLUSION

This case study represents a successful ortho-k fitting for a high myopic patient with moderate anisometropia. Toric ortho-k lenses were able to provide a complete reduction in the refractive status, and the patient enjoyed her spectacle- and contact lens–free vision with no effect on ocular health.

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