

Silicone Hydrogel Orthokeratology for the Correction of Low Myopia

Thesis

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Abstract

Aim

Patrick J. Caroline and Mark P. Andre first reported about soft lens orthokeratology in 2005. In a number of articles in the past five years, they reported about their research on this topic and their new findings. The aim of this study was to continue the research of Patrick J. Caroline and Mark P. Andre and to collect more information about the outcome of the technique.

Methods

Ten subjects with low myopia from -0.25 D to -1.25 D and a refractive astigmatism from plano to -0.75 D were fitted with a -10.00 D CIBA VISION AIR OPTIX® NIGHT&DAY® silicone hydrogel contact lens and were told to wear the lenses over night and everted. Corneal topography and refraction measurements were taken after one night, one week and one month of contact lens wear.

Results

Eight out of ten subjects finished the study, six female and two male. The mean age of the subjects was 23.9 years. With the eight subjects who finished the study, the mean change in subjective refraction was about +1.00 D in the sphere and +0.22 D in the cylinder, with maximum changes of +1.75 D sphere and +0.75 D cylinder. The mean apical power change, measured with the topographer, was 1.11 D. Changes in K – readings ranged from slight corneal steepening in both of the meridians to 0.23 mm of corneal flattening in the horizontal meridian and 0.27 mm of corneal flattening in the vertical meridian. Corneal eccentricity decreased about 0.65 on average. The main complaints and problems were the high minus power and the decentration of the contact lens and the occurrence of ghosting at night.

Conclusion

The results of this study show that everted wear of a high minus silicone hydrogel contact lens can lead to orthokeratology – such as changes in corneal topography and subjective refraction. These changes range from plano to +1.75 D sphere and +0.25 D to +0.75 D cylinder but are unpredictable and vary from subject to subject. Additional studies regarding the contact lens decentration and the unpredictability of the outcome need to be done to optimize the process.

Keywords: Orthokeratology, Myopia

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List of Abbreviations

CL	Contact Lens
Cyl	Cylinder
D	Diopter
Dk/t	Value for the oxygenpermeability of a contact lens material
Ecc.	Eccentricity
K – Reading	Radius of a corneal meridian
PMMA	PolyMethyl Methacrylate
RGP	Rigid Gas Permeable
SCL	Soft Contact Lens
Sph	Sphere
OD	Oculus Dexter (right eye)
OS	Oculus Sinister (left eye)
OU	Oculus Uterque (both eyes)
VA	Visual Acuity

1 Orthokeratology

In 1971, the International Orthokeratology Section of the National Eye Research Foundation defined Orthokeratology as "the reduction, modification or elimination of refractive anomalies by the programmed application of contact lenses". Orthokeratology, also called OK, ortho – k, corneal reshaping, corneal refractive therapy (CRT) or vision shaping treatment (VST) is a special technique to temporarily modify or eliminate refractive error. The contact lenses used are usually rigid gas permeable contact lenses that are specially designed and fitted to reshape the corneal contour. The reduction of myopia through corneal flattening is nowadays the most common application of orthokeratology.⁹

1.1 Orthokeratology with Rigid Gas Permeable Contact Lenses

1.1.1 History

It is said that ancient Chinese slept with small weights or sandbags on their eyelids to reduce myopia. These stories are unconfirmed but the principle is similar to modern orthokeratology.

In 1888, Eugene Kalt used flat - fitting glass scleral contact lenses for keratoconic patients to apply pressure against the cone.

With the introduction of polymethyl methacrylate (PMMA) contact lenses in the 1950s, practitioners noticed unintended changes in refraction and corneal curvature with flat - fitting contact lenses. A lot of young myopic patients showed no progression in myopia with flat – fitting lenses. This led to trials of controlled corneal flattening with contact lenses to modify myopia.

In 1962, George Jessen first described his "orthofocus" technique where he used plano – powered lenses that were fitted flatter than corneal curvature by the amount of myopia. The emerging post – lens tear fluid lens was used to correct the amount of myopic refractive error. This fitting technique showed corneal flattening and improved unaided vision after contact lens removal.

Conventionally designed flat – fitting lenses were used in the 1960s and 1970s by a number of practitioners to experiment with the technique. To achieve better stabilization of the flat – fitting lenses on the cornea, some of these practitioners started to manipulate different lens parameters. It was not until the invention of the reverse geometry lens design in the 1990s that the problem of lens centration was solved.

In 1971 orthokeratology was defined as "the reduction, modification or elimination of refractive anomalies by the programmed application of contact lenses" by the International Orthokeratology Section of the National Eye Research Foundation.

From 1976 to 1978, Kerns used large diameter PMMA lenses fitted flatter than K (as traditional daily – wear orthokeratology) and conventional PMMA lenses fitted in corneal alignment for a three year study. Modest reductions in myopia were found in both groups but only the orthokeratology group showed less corneal asphericity. Kerns concluded that corneal sphericity is the end – point of orthokeratology treatment.

In 1983, Polse et al examined the regression of the refractive effect after discontinuing lens wear and found that the refractive effect was temporary. Due to these findings, they stated that the procedure was safe.

As the goal was to induce a permanent reduction in myopia, the regression of the refractive effect and the induction of significant regular and irregular astigmatism in some patients were considered a disappointment. For that reason, Orthokeratology remained a rarely used technique for the next ten years.

The impermeability to oxygen of the PMMA contact lens material only allowed open – eye wear to avoid hypoxia. The invention of rigid gas – permeable materials in the late 1980s led to the birth of overnight orthokeratology and provided the patients with clear unaided vision during the day.

Computerised corneal topographic mapping devices were brought into reach of many clinical practices by the early 1990s. This allowed accurate screening of orthokeratology patients and assisted in lens design and fitting.

The development of the reverse – geometry contact lens design by Wlodyga and Stoyan in the 1990s led directly to the recent growth in interest in orthokeratology. Exact information about the reverse – geometry lens design are listed in chapter 1.1.2. Nowadays, four- or five – curve reverse – geometry lenses in high Dk materials are used in an overnight lens – wearing modality.^{8,9}

1.1.2 Reverse geometry lens design

Reverse geometry design contact lenses are made of four different curves on the back surface of the lens. These curves create the topographical changes in orthokeratology.

Back Optic Zone Radius (BOZR)

A flat central curve with a back optic zone diameter of about 6 mm. It provides a subtle applanation force on the cornea and the resulting positive pressure creates the necessary forces to re – distribute the tissue.

Alignment/Fitting Curve Radius

The first back peripheral optic radius is a 1 – 1.3 mm wide mid – peripheral curve and is the actual fitting portion of the lens. It creates the alignment to the mid – peripheral cornea to control lens movement and position. This curve can be spherical, aspherical or tangential.

Reverse Curve Radius

The second back peripheral optic radius completes the construction of the tear reservoir. It joins the alignment/fitting curve with the BOZR and is about 0.6 mm wide.

Peripheral Curve Radius

The Peripheral Curve Radius is the flat, third back peripheral optic radius that provides peripheral corneal clearance to facilitate lens movement and tear exchange and is 0.4 mm wide.³

1.1.3 Eccentricity

The surface of the cornea is just by approximation a spherical or toric surface. At closer observation, the cornea flattens gradually from the center to the periphery. This flattening is different in each meridian. The eccentricity specifies the average value of this flattening and can be measured with the topographer. The average eccentricity amounts to 0.45.

As orthokeratology flattens the cornea, the amount of flattening can also be observed with the eccentricity change. Usually, the eccentricity decreases or even becomes negative under orthokeratology treatment.^{2,10}

1.1.4 Patient's suitability

Usually, patients express a personal or occupational interest to become less dependent on the full – time use of contact lenses or spectacles or have an underlying psychological desire to stop the progression of their myopia. The main goal of orthokeratology is to provide functional 20/20 visual acuity. Desirable characteristics of an orthokeratology patient are spherical myopic refractive errors from -0.75 to -4.00 D, with – the – rule astigmatism up to -1.50 D, occupational, recreational or social requirements for improved unaided vision and a clear understanding of a realistic visual outcome.³

1.1.5 Fitting

The fitting of reverse geometry lenses can be performed empirically or diagnostically. A fitting guide can be used for the empirical fitting, where the different lens radii, the lens diameter and power are calculated by the contact lens specialist. For the diagnostic lens fitting, the fluorescein pattern needs to be interpreted by placing an appropriate diagnostic lens on the eye and instill fluorescein. The fluorescein pattern of a well fitted orthokeratology lens should exhibit:

- a centred lens portion
- 1 to 1.5 mm mid – peripheral alignment/bearing in the area of the alignment/fitting curve
- fluorescein pooling in the area of the reverse curve
- 360 degrees of peripheral lens clearance
- 1 mm of blink induced lens movement

For the post – fitting corneal topography, Mountford described a central "bull's –eye" pattern as a proof of a well – centred orthokeratology lens.^{3,11,12}

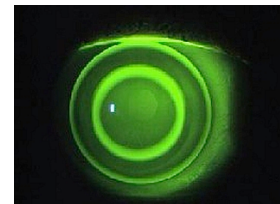


Figure 1: Fluorescein Pattern Orthokeratology

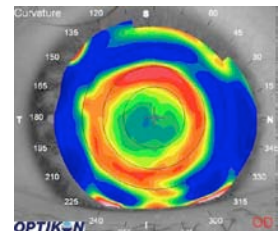


Figure 2: Topography after Orthokeratology

1.2 Orthokeratology with Soft Contact Lenses

In 2005, Patrick J. Caroline and Mark P. Andre first reported topographical and refractive changes with everted silicone hydrogel lens wear. To test this, P.J. Caroline wore an everted -10.00 D Ciba Vision Night&Day lens on his amblyopic left eye for a period of 30 days. Corneal topography measurements were taken after the fitting, after 10 hours, one week and four weeks of lens wear. After 10 hours of overnight wear, the area close to the central cornea showed about -1.50 D of concentric flattening surrounded by a zone of midperipheral steepening.

At the one – week follow – up, the central apical power had flattened -1.37 D. The topographical image showed a zone of less topographical change that they called "central island" that was surrounded by a concentric zone of greater flattening with -4.50 D at its flattest point. A concentric zone of corneal steepening was noted in the mid – periphery.

At the four week visit, the corneal flattening reached -3.12 D with a flattening of -6.75 D in the mid – peripheral cornea. The "central island" remained evident.

Caroline and Andre concluded that the wearing of everted silicone hydrogel contact lenses can result in significant topographical changes and that the comfort of these everted contact lenses persists for the patient for up to 30 days.⁴

In 2006, Caroline and Andre published a second article on the topographical changes after everted silicone hydrogel lens wear. They reported about a -13.00 D myope with symptoms of blurred vision in his left eye. He was wearing his CIBA Vision soft contact lenses for about 10 years with 20/25 vision OU and comfortable all – day lens wear. The fluorescein pattern of the left eye showed a corneal imprint caused by wearing the lens inside – out. The corneal mapping showed the beginning of a slight ring pattern.

In a study about contact lens comfort at Pacific University, 12 non – adapted lens wearers were fit with -10.00 D soft contact lenses. The lenses were applied right – side – in on one eye and inside – out on the other eye. The patients had to rate lens comfort from 0 to 10, where 0 represented poor lens comfort and 10 excellent comfort. The study showed no significant difference in lens comfort of right – side – in and inside – out lens wear.⁵

The observed refractive and corneal changes and the study about contact lens comfort led to the attempt to perform orthokeratology on patients with low myopia using everted, high – Dk silicone hydrogel contact lenses. The first trial was performed on a -1.00 D OU myope, using a -9.50 D soft contact lens, base curve 8.4 mm, diameter 13.8 mm, worn inside – out. The examinations after one night and one week showed an uncorrected visual acuity of 20/20 in both eyes and the patient reported excellent overnight comfort.⁶

Further trials of this modality led to the following conclusions about visual and topographical outcome:

1. Corneal flattening of approximately 0.50 D to 1.75 D
2. Good lens centration and comfort
3. Greatest effects occur with silicone hydrogel lenses that have a higher modulus
4. Contact lens powers from -9.00 D to -10.00 D show the greatest flattening
5. The amount of flattening is unpredictable and varies from patient to patient
6. Higher minus lenses than -10.00 D result in central corneal steepening
7. Formation of a zone of central corneal steepening is the number one complication that can be resolved by a slight decrease of contact lens power⁷

1.3 Purpose of the study

The idea of a continuing study on the topic of soft lens orthokeratology evolved during the author's stay at Pacific University in 2009, where Patrick J. Caroline explained the technique and outcome in a lecture about orthokeratology. The innovation of the technique and the high research potential led to the decision to perform soft lens orthokeratology on a selected group of subjects with a defined range of refractive error.

The purpose of the study was to collect a high number of new information about the outcome of the technique and to continue the research of Patrick J. Caroline and Mark P. Andre.

2 Materials

2.1 Contact Lens

CIBA VISION AIR OPTIX[®] NIGHT&DAY[®]

Power	Diameter	Base Curve	Material	Modulus	Dk/t
-10.00 D	13.8 mm	8.40 mm	lotrafilcon A	1.4	175

Table 1: CIBA VISION AIR OPTIX NIGHT&DAY

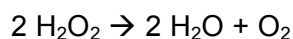
The CIBA VISION AIR OPTIX[®] NIGHT&DAY[®] is a high – Dk silicone hydrogel contact lens with a water content of 24%. It is approved for continuous wear up to 30 days. The lens is made of lotrafilcon A and has a high modulus of 1.4. The design is asperic.¹³

2.2 Cleaning Solution

The only contact lens cleaning solution used in this study was the CIBA VISION AOSEPT[®] PLUS, a preservative – free, 3% hydrogen peroxide solution. AOSEPT[®] PLUS is approved for all soft and rigid gas permeable contact lenses. The neutralisation of the hydrogen peroxide happens through the platinum disc that is integrated in the contact lens case. During the neutralization, hydrogen peroxide resolves into water and oxygen:



Figure 3: AOSEPT PLUS



Hydrogen peroxide is known for its reliable disinfections and is often used for people with allergies and persons who tend to have a high amount of deposits on their contact lenses.^{1,14}

At the request of some of the subjects, the CIBA VISION SoftWear Saline was dispensed in addition to the AOSEPT[®] PLUS. It is a preservative – free saline that can be used for rinsing the contact lenses or cleaning the contact lens case.¹⁵



Figure 4: SoftWear Saline

2.3 Topographer

The OCULUS Keratographer combines a topography – system and a keratometer. It is composed of 22 placido – rings and measures 22.000 testing points on the cornea. According to OCULUS, the accuracy is about ± 0.1 D and the repeatability about ± 0.1 D. The working distance amounts to 80 mm.^{16,17}

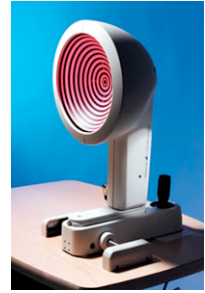


Figure 5: OCULUS Kertographer

2.3.1 Overview display

The overview display shows a picture of the eye with the image of the placido rings on the cornea. This is the area of the measurement. Below the picture is a table that includes the corneal curvatures (horizontal and vertical), the corneal astigmatism, the axis of the astigmatism, the eccentricity and the corneal diameter. On the right side is the topographic map of the cornea and the picture below this map shows the flattening of the cornea.¹⁶

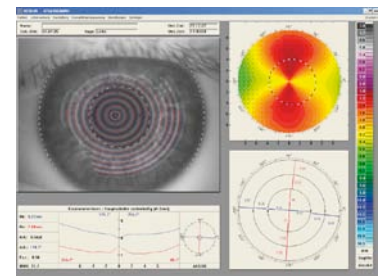


Figure 6: Overview Display

2.3.2 Refractive compare

The refractive compare display is used to show alterations of the refraction power after refractive surgery or orthokeratology. In this study, the baseline topography was compared to the particular follow – up topographies to monitor the objective refractive change on the cornea.¹⁶

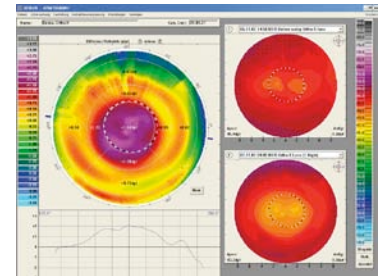


Figure 7: Refractive Compare Display

3 Methods

3.1 Subjects

At the beginning of the study, the author recruited 10 subjects with the following requirements:

- sphere: plano to -1,25 D
- astigmatism: plano to -0,75 D
- spherical equivalent: <1.50 D
- no current or former eye disease that affect orthokeratology treatment

8 out of 10 subjects finished the study.

All of the subjects were fitted with the CIBA VISION AIR OPTIX[®] NIGHT&DAY[®], base curve 8.4 mm, -10.00 D, diameter 13.8 mm. The classification of the diagnostic findings is based on the book "Klassifikation von Spaltlampenbefunden" by Wolfgang Sickenberger and is fairly similar to the Vistacon CCLRU grading scales.

3.2 Contact Lens Wearing Instructions

Every subject wore the lenses for at least four weeks. The subjects were told to wear the lenses every night. The wearing of other contact lenses and the usage of a different cleaning solution was prohibited. The subjects had to participate in every determined follow-up. Instructions in the usage of the cleaning solution and in the handling of the contact lenses were given by the author.

The contact lenses were inserted in the evening before the subjects went to sleep. The subjects had to make sure that the contact lenses are everted. If needed, the contact lenses could be rinsed with the CIBA VISION SoftWear Saline. In the morning, the contact lenses were removed and stored in the CIBA VISION AOSEPT[®] PLUS.

3.3 Measurements and Examinations

The measurements were taken on the day of the fitting (visit 1), after the first night (visit 2), after one week (visit 3) and after four weeks. All of the follow-up measurements were taken in the morning. At the four-week measurement, topographies and refraction were taken in the morning (visit 4) and in the evening (visit 5) to control the change of refraction during the day.

3.3.1 Baseline

On the day of the fitting of the contact lenses, topographies were measured with the OCULUS Keratographer to get the baseline data of the cornea. The anterior part of the subject's eyes was examined with the Bon Digi Pro 2 Slit Lamp. Subjective refraction was performed with the Cross – Cylinder – Method. The subjects were instructed in the handling of the contact lenses and the usage of the cleaning solution.

3.3.2 Follow – up

Every follow up started with measuring the topography of each eye to monitor the topographical changes on the cornea. An autorefractor measurement was taken as an initial value for the overrefraction. The overrefraction was performed with the Cross – Cylinder – Method. The measurements were followed by a slit lamp examination to guarantee the health of the eye. In addition to the slit lamp examination, fluorescein was applied on each eye to examine the surface of the cornea.

4 Results

4.1 B. W.

Visit 1: 04/15/2010 at 2:00pm

Patient History:

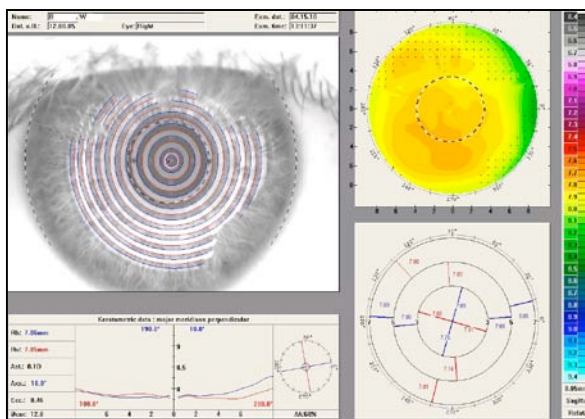
B.W. is a 24 year old white female student, with unremarkable ocular and systemic histories. She is not currently taking any medication, and has no known allergies. She has never worn any type of contact lenses before. Slit lamp examination showed grade 2 injection on the inferior sclera OD.

Refraction:

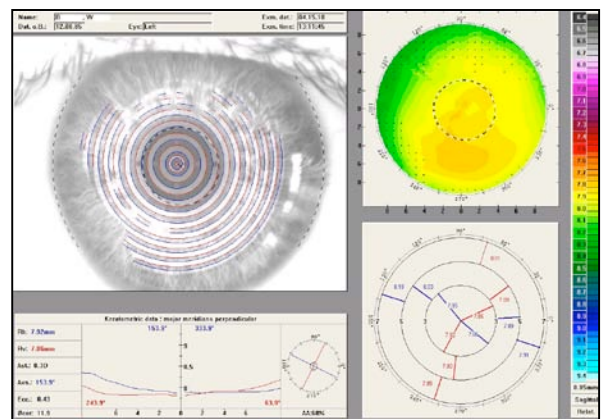
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.00	-0.50	83	20/12
OS	20/12	-0.00	-0.50	108	20/12

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.86	7.85	0.46
OS	7.92	7.86	0.43

Visit 2: 05/04/2010 at 1:00pm

B.W. was wearing the CIBA VISION AIR OPTIX[®] NIGHT&DAY[®] the night before for about six hours. She reported a strong foreign body sensation in the evening and discomfort because of the high power of the contact lens. Slit lamp examination showed no abnormalities.

Refraction:

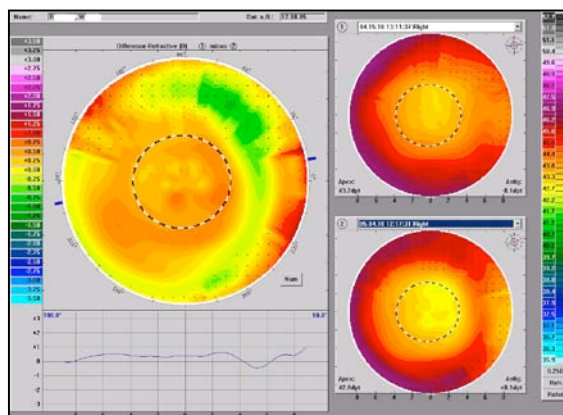
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.25	-0.25	90	20/12
OS	20/15	-0.50	-0.75	113	20/12

K – Readings:

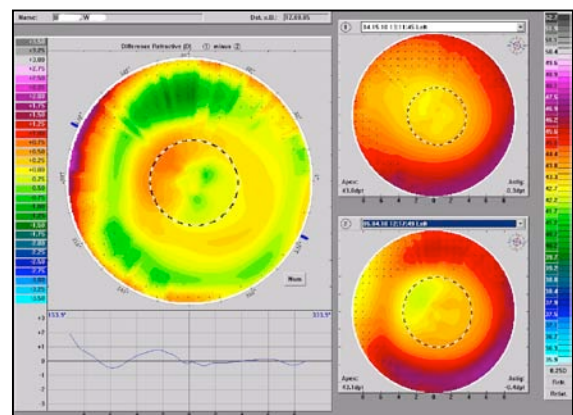
	horizontal (mm)	vertical (mm)	ecc.
OD	7.91	7.93	0.22
OS	7.96	7.89	0.36

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.39	+0.41
OS	-0.07	-0.10

Visit 3: 05/11/2010 at 7:30am

B.W. was wearing the contact lenses every night for one week. She reported no further foreign body sensation and there were no conspicuous slit lamp findings.

Refraction:

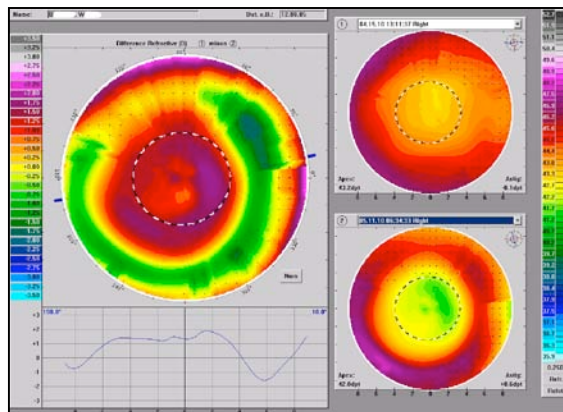
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/15	+0.50	-0.00	0	20/15
OS	20/15	+1.00	-0.50	120	20/15

K – Readings:

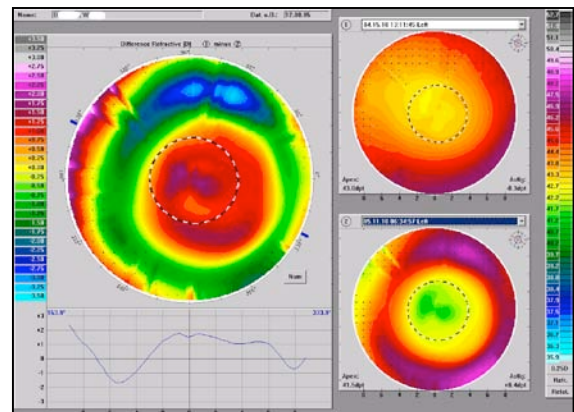
	horizontal (mm)	vertical (mm)	ecc.
OD	7.94	8.05	-0.00
OS	7.93	8.00	-0.21

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.34	+1.33
OS	+1.64	+1.51

Visit 4: 06/08/2010 at 7:30am

After wearing the contact lenses for four weeks, B.W. reported good overall lens comfort but no entire satisfaction with her subjective visual acuity. In addition, she observed some ghosting at night.

Refraction:

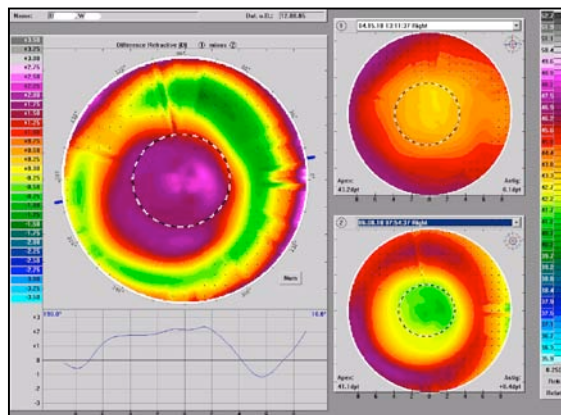
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	+0.75	-0.25	85	20/10
OS	20/10	+1.00	-0.50	145	20/10

K – Readings:

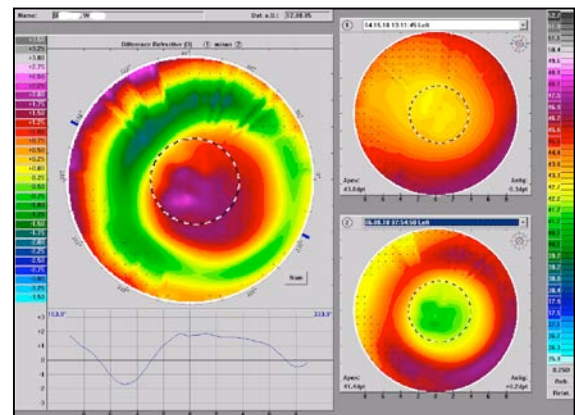
	horizontal (mm)	vertical (mm)	ecc.
OD	8.04	8.12	0.04
OS	7.94	7.98	0.04

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+2.13	+2.04
OS	+1.72	+1.62

Visit 5: 06/05/2010 at 5:30pm

At the final visit, B.W. was content with the overall contact lens comfort. She complained about the blurred vision while wearing the contact lenses. Due to her good visual acuity without wearing any type of contact lens, she did not want to continue wearing her contact lenses.

Refraction:

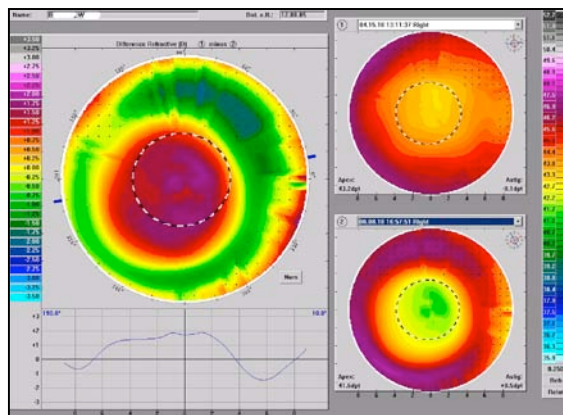
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	+0.50	-0.50	82	20/10
OS	20/12	+0.75	-0.50	110	20/10

K – Readings

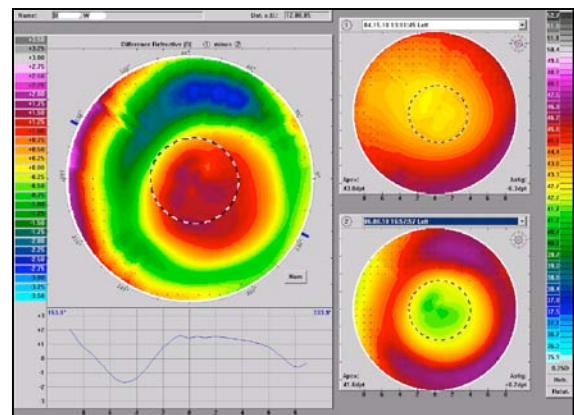
	horizontal (mm)	vertical (mm)	ecc.
OD	7.90	7.99	-0.18
OS	7.92	7.95	0.01

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.72	+1.69
OS	+1.47	+1.44

4.2 J. C.

Visit 1: 04/07/2010 at 1:15pm

Patient History:

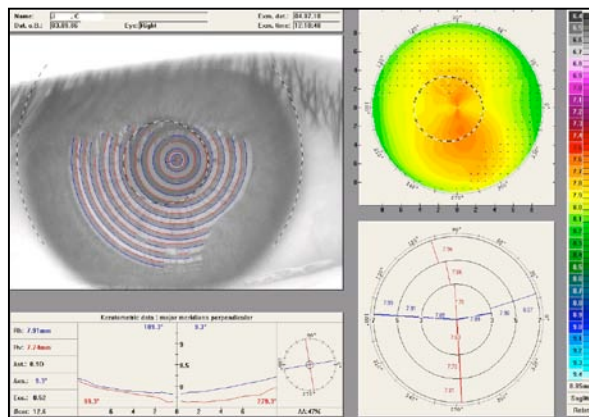
J.C. is a 24 year old white male student, with unremarkable ocular and systemic histories. He is not currently taking any medication, and has no known allergies. He has worn daily or monthly disposable contact lenses before. Slit lamp examination showed no abnormalities.

Refraction:

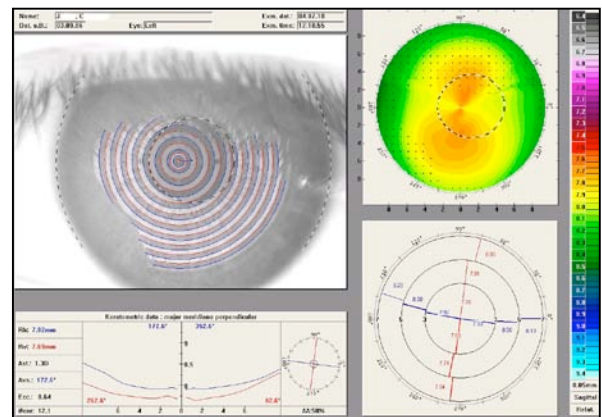
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	-0.25	-0.75	10	20/12
OS	20/20	+0.25	-1.25	0	20/12

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.91	7.74	0.52
OS	7.92	7.69	0.64

Visit 2: 04/08/2010 at 7:30am

J.C. was wearing the CIBA VISION AIR OPTIX[®] NIGHT&DAY[®] for about 6 hours the night before. He reported a strong foreign body sensation the whole night and double vision in the left eye. He complained about the blurred vision due to the high powered lenses. Slit lamp examination showed no abnormalities.

Refraction:

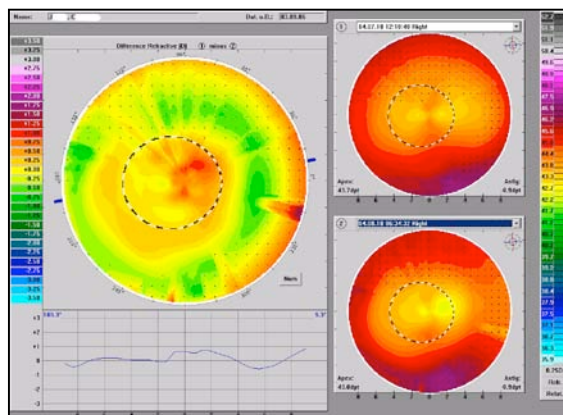
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.00	-1.00	13	20/12
OS	20/15	+0.25	-1.50	0	20/12

K – Readings:

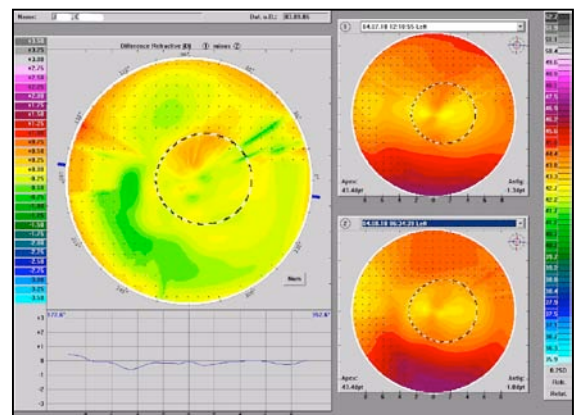
	horizontal (mm)	vertical (mm)	ecc.
OD	7.96	7.79	0.48
OS	7.99	7.80	0.65

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.56	+0.68
OS	-0.41	-0.01

Visit 3: 04/15/2010 at 10:15am

At the one week follow-up, J.C. was wearing the contact lenses 9-12 hours every night for one week. He reported no further foreign body sensation but complained about bad subjective visual acuities.

Refraction:

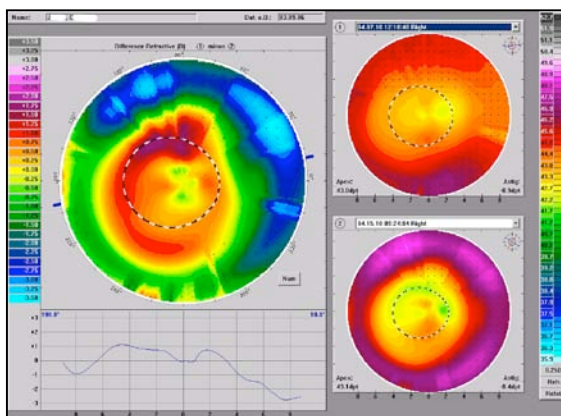
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/25	+0.75	-1.00	20	20/12
OS	20/30	+0.75	-1.00	177	20/12

K – Readings:

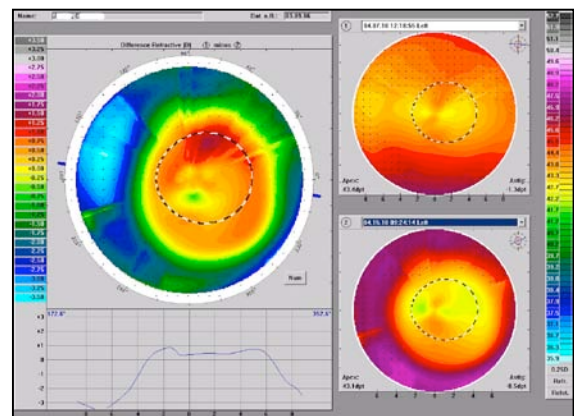
	horizontal (mm)	vertical (mm)	ecc.
OD	7.94	7.87	-0.56
OS	7.93	7.83	-0.10

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.84	+0.61
OS	+0.41	+0.30

Visit 4: 05/06/2010 at 7:30am

Between the visit 3 and visit 4, J.C. did not wear the lenses for one night. He reported double vision and ghosting

Refraction:

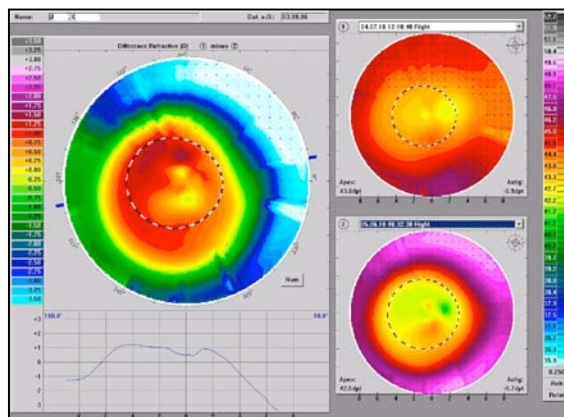
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	+1.00	-1.00	10	20/15
OS	20/20	+0.75	-1.25	175	20/12

K – Readings:

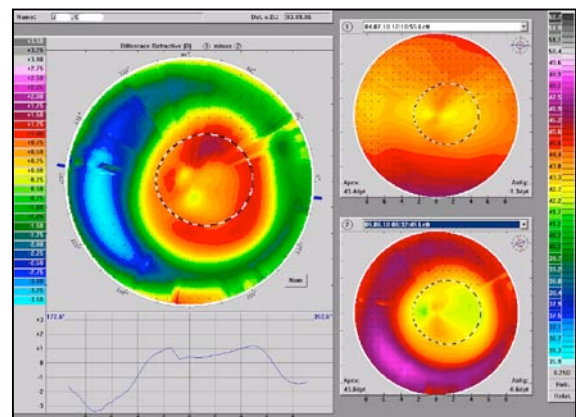
	horizontal (mm)	vertical (mm)	ecc.
OD	7.96	7.83	-0.62
OS	8.04	7.93	-0.24

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.41	+1.16
OS	+0.40	+0.42

Visit 5: 06/05/2010 at 5:30pm

At his final visit, J.C. complained about the bad subjective visual acuity, the ghosting and the double vision throughout the four weeks of contact lens wear. He did not continue wearing the contact lenses.

Refraction:

	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	+1.00	-1.00	10	20/12
OS	20/20	+0.75	-1.75	170	20/10

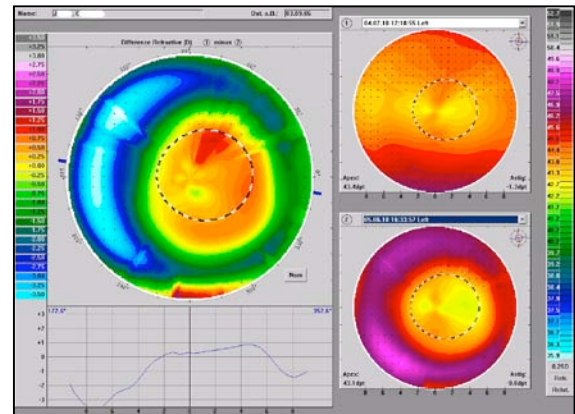
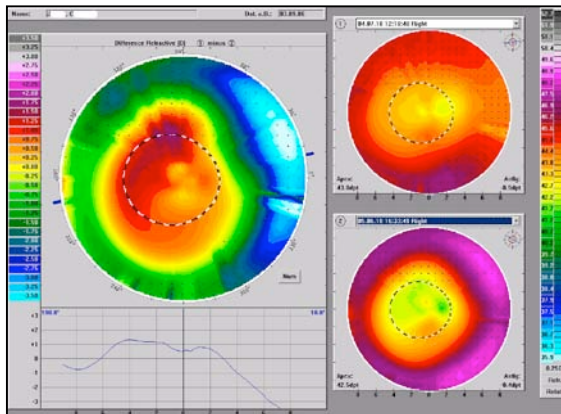
K – Readings

	horizontal (mm)	vertical (mm)	ecc.
OD	7.93	7.86	-0.54
OS	7.89	7.78	-0.21

Refractive Compare:

OD:

OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.20	+1.21
OS	+0.33	+0.30

4.3 K. S.

Visit 1: 04/15/2010 at 5:00pm

Patient History:

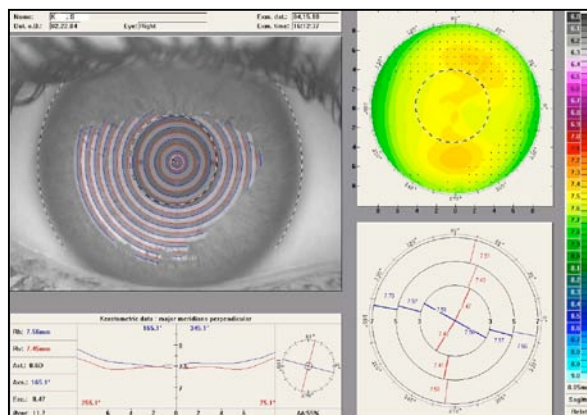
K.S. is a 26 year old white female. She works as a Dipl. Ing. of technical sales and distribution. Her ocular and systemic histories are unremarkable. She is not currently taking any medication, and has no known allergies. She has worn monthly disposable contact lenses before. Slit lamp examination showed grade 2 injections around the limbus OU. She wore a lot of eye make – up and her tear film contained a lot of oily make – up leftovers.

Refraction:

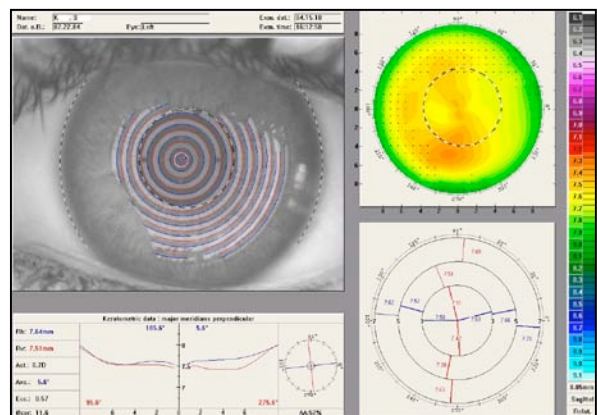
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/50	-1.25	-0.25	175	20/12
OS	20/50	-1.00	-0.50	25	20/12

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.56	7.45	0.47
OS	7.64	7.51	0.57

Visit 2: 05/07/2010 at 7:30am

K.S. showed up with a red eye OD. She used the hydrogen peroxide cleaning solution to rinse the right lens before insertion the last night and was wearing the contact lens for about 8.5 hours over night. Slit lamp examination with fluorescein showed grade 4 corneal and scleral staining OD. She reported good lens comfort in her left eye.

Refraction:

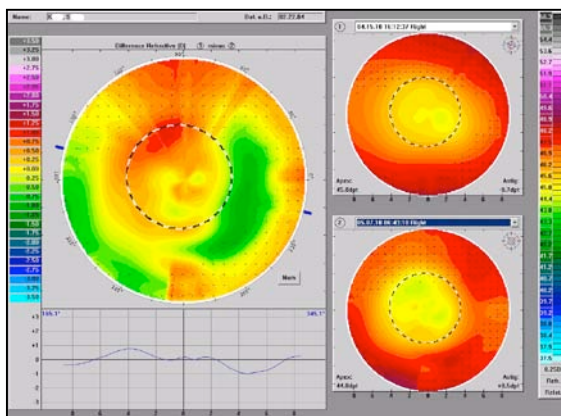
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	-1.00	-0.25	120	20/15
OS	20/15	-0.50	0.00	0	20/12

K – Readings:

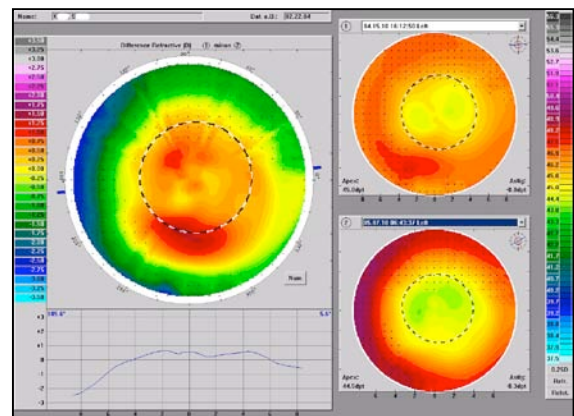
	horizontal (mm)	vertical (mm)	ecc.
OD	7.55	7.63	0.39
OS	7.73	7.67	-0.19

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.05	+0.01
OS	+0.59	+0.55

Visit 3: 05/14/2010

After wearing the contact lenses for one week, K.S. reported good lens comfort and good subjective visual acuity. She complained about the blurred vision while wearing the -10.00 D contact lens. She showed slight three and nine o'clock staining OU.

Refraction:

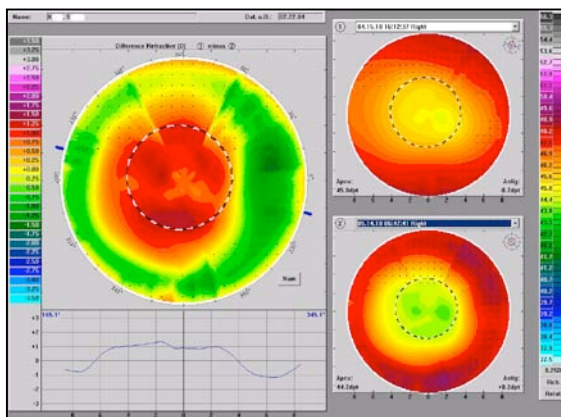
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.25	0.00	0	20/12
OS	20/12	0.00	0.00	0	20/12

K – Readings:

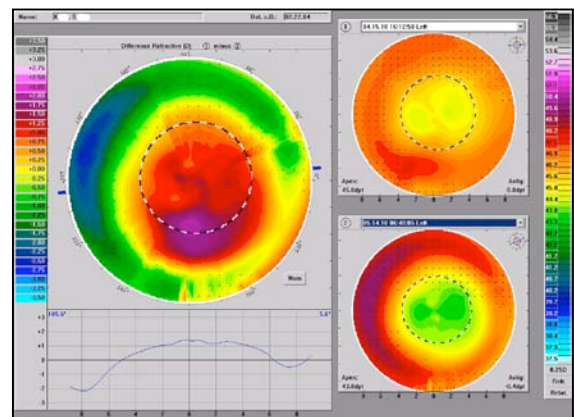
	horizontal (mm)	vertical (mm)	ecc.
OD	7.62	7.66	-0.34
OS	7.74	7.67	-0.32

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.49	+0.46
OS	+1.14	+1.15

Visit 4: 06/04/2010

At the four week follow – up, K.S. was very happy with the comfort and visual outcome of the contact lenses. There were no remarkable slit lamp findings.

Refraction:

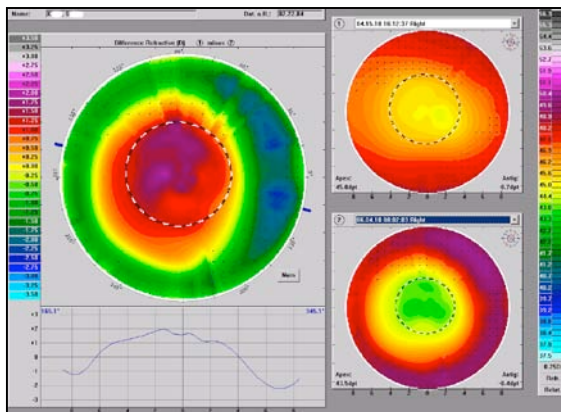
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	0.00	-0.25	15	20/12
OS	20/12	+0.50	0.00	0	20/12

K – Readings:

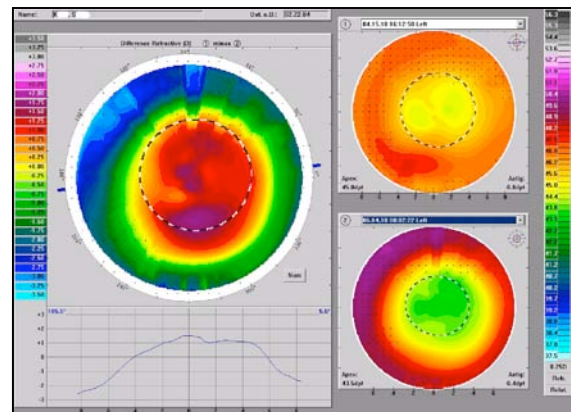
	horizontal (mm)	vertical (mm)	ecc.
OD	7.68	7.61	-0.55
OS	7.72	7.65	-0.58

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.63	+0.50
OS	+0.97	+0.95

Visit 5: 06/04/2010 at 6:30pm

Reviewing the past four weeks, K.S. is very happy with the visual outcome of this contact lens wearing modality. She would continue wearing the contact lenses on a daily basis. Her only complaint is the blurred vision with the -10.00 D lens.

Refraction:

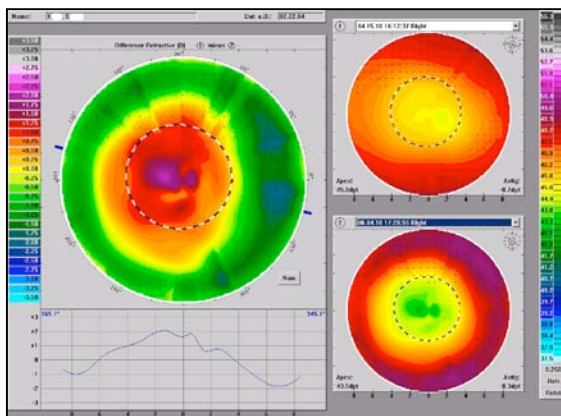
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/15	0.00	-0.50	13	20/10
OS	20/10	0.00	0.00	0	20/10

K – Readings

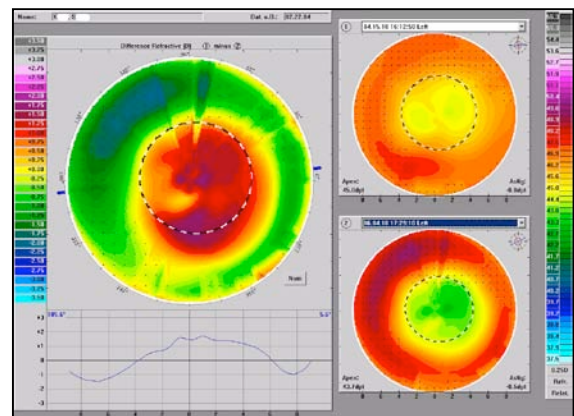
	horizontal (mm)	vertical (mm)	ecc.
OD	7.64	7.50	-0.43
OS	7.71	7.61	-0.27

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	-0.07	+0.05
OS	+0.61	+0.60

4.4 N. M.

Visit 1: 04/20/2010 at 1:30pm

Patient History:

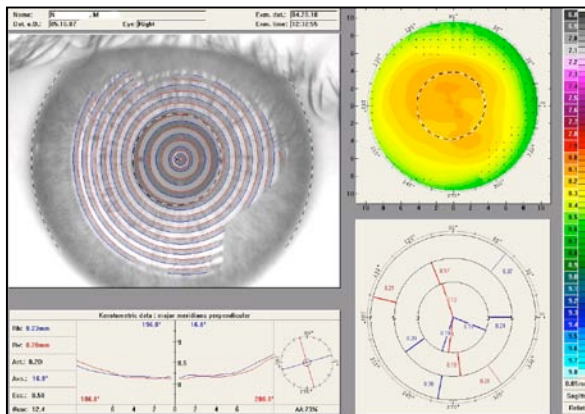
N.M. is a 23 year old white female student. She is currently wearing RGP lenses. Her ocular and systemic histories are unremarkable. She is not currently taking any medication and has no known allergies. Slit lamp examination showed no abnormalities.

Refraction:

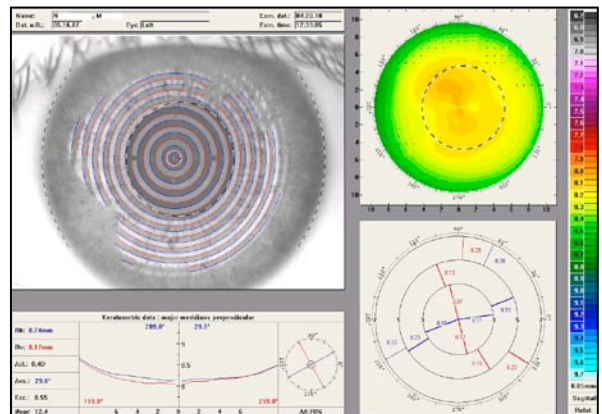
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/15	-0.25	-0.50	90	20/10
OS	20/20	-0.75	-0.25	65	20/10

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	8.23	8.20	0.58
OS	8.24	8.17	0.55

Visit 2: 04/23/2010 at 8:00am

After one night of wearing the contact lenses, N.M. reported good lens comfort and good subjective visual acuity. She wore the lenses for about eight hours the night before and complained about blurred vision with the hight powered contact lens. There were no remarkable slit lamp findings.

Refraction:

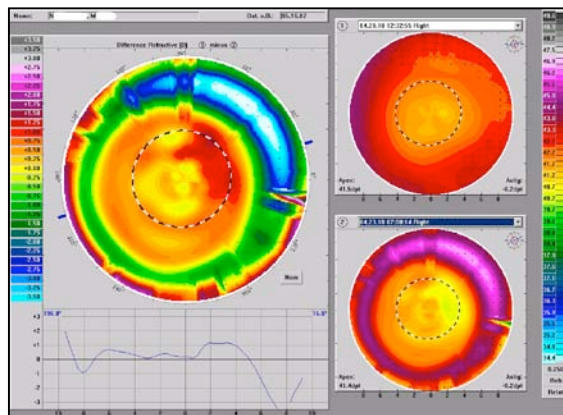
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	0.00	-0.25	71	20/12
OS	20/12	-0.25	0.00	0	20/12

K – Readings:

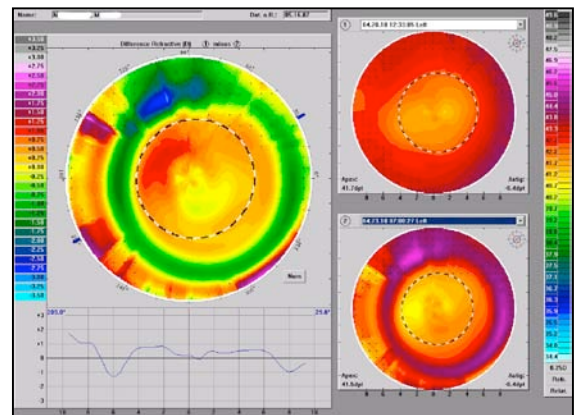
	horizontal (mm)	vertical (mm)	ecc.
OD	8.31	8.27	-0.30
OS	8.36	8.28	0.29

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.18	+0.09
OS	+0.10	+0.25

Visit 3: 04/30/2010 at 07:45am

At the one week follow-up, N.M. complained about a dry eye after contact lens removal and that the lens on her left eye decenters superiorly. Slit lamp examination with fluorescein showed grade 2 staining at 3 and 9 o'clock staining OS.

Refraction:

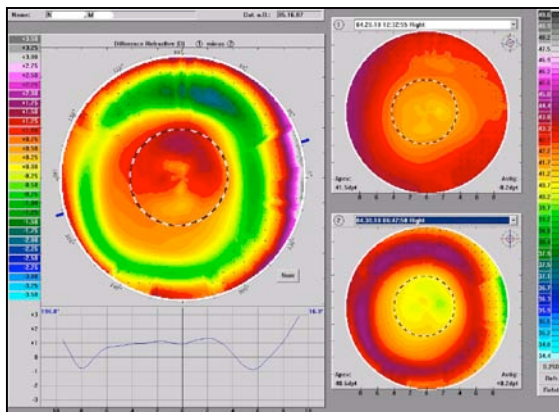
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/10	0.00	0.00	0	20/10
OS	20/10	+0.25	0.00	0	20/10

K – Readings:

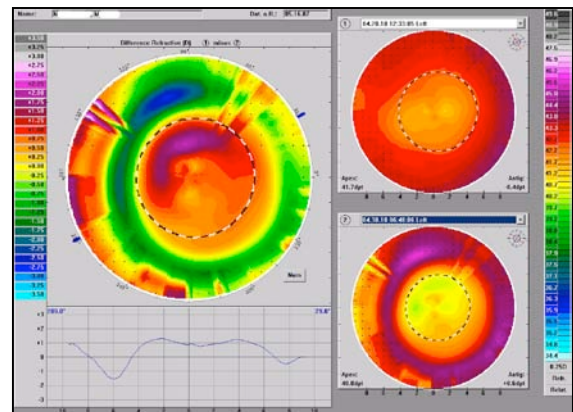
	horizontal (mm)	vertical (mm)	ecc.
OD	8.35	8.39	0.37
OS	8.21	8.34	0.16

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.97	+0.78
OS	+0.92	+0.85

Visit 4: 06/04/2010 at 09:30am

After four weeks of contact lens wear, N.M. reported good overall lens comfort and good subjective visual acuity. There were no remarkable slit lamp findings.

Refraction:

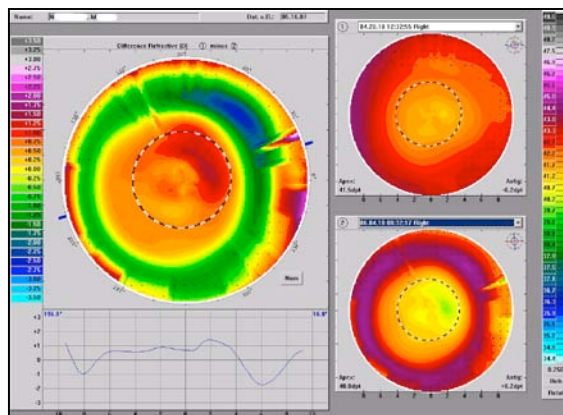
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/10	+0.25	-0.25	65	20/10
OS	20/10	0.00	0.00	0	20/10

K – Readings:

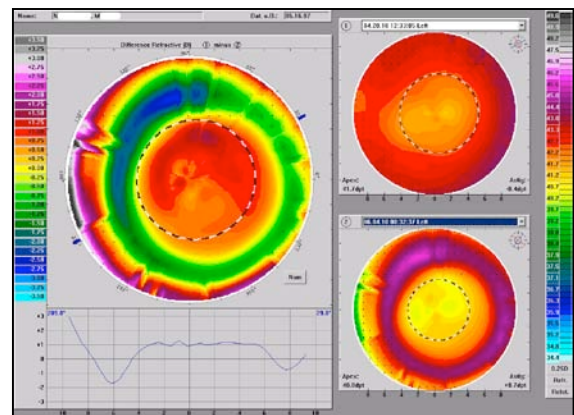
	horizontal (mm)	vertical (mm)	ecc.
OD	8.25	8.29	0.13
OS	8.18	8.33	0.21

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.71	+0.66
OS	+0.88	+0.92

Visit 5: 06/04/2010 at 5:00pm

At the final visit, N.M. reports, that she felt very comfortable with the lenses throughout the whole study. She would continue wearing the lenses but complains about the -10.00 D power of the lenses.

Refraction:

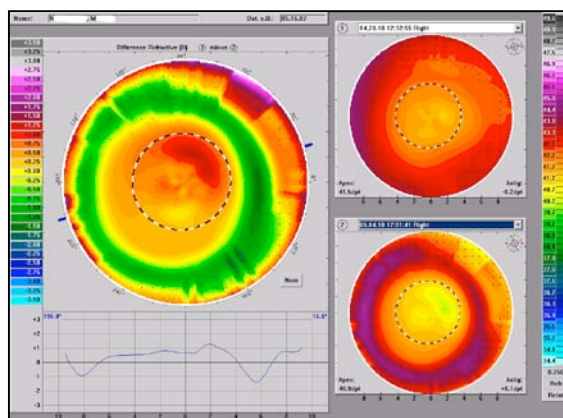
	uncorrected VA	sph (dpt)	cyl (dpt)	axis (°)	VA
OD	20/10	+0.25	-0.25	65	20/10
OS	20/10	0.00	0.00	0	20/10

K – Readings

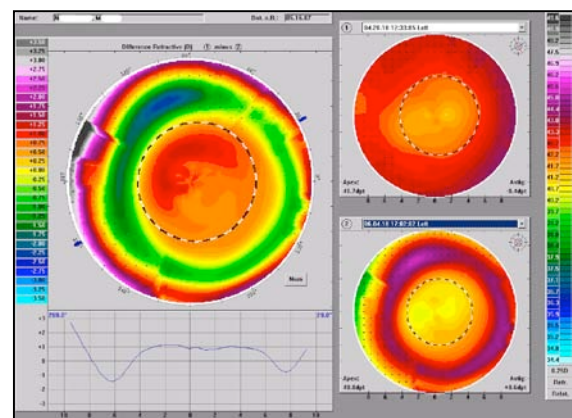
	horizontal (mm)	vertical (mm)	ecc.
OD	8.22	8.25	0.32
OS	8.18	8.31	0.43

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.62	+0.57
OS	+0.88	+0.88

4.5 P. M.

Visit 1: 04/21/2010 at 2:30pm

Patient History:

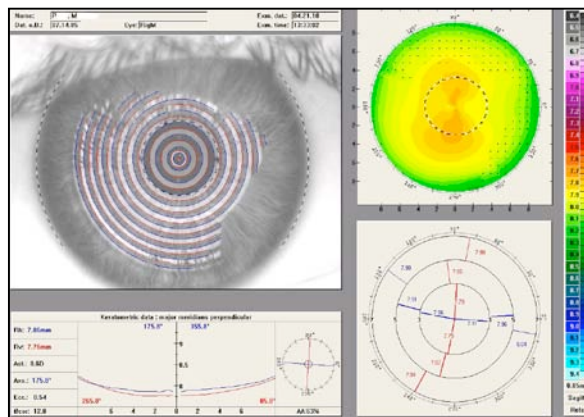
P.M. is a 24 year old white male student. He is currently wearing daily disposable contact lenses once or twice a week. He has unremarkable systemic and ocular histories and is not currently taking any medication. He tends to have slight seasonal allergies. Slit lamp examination showed no abnormalities.

Refraction:

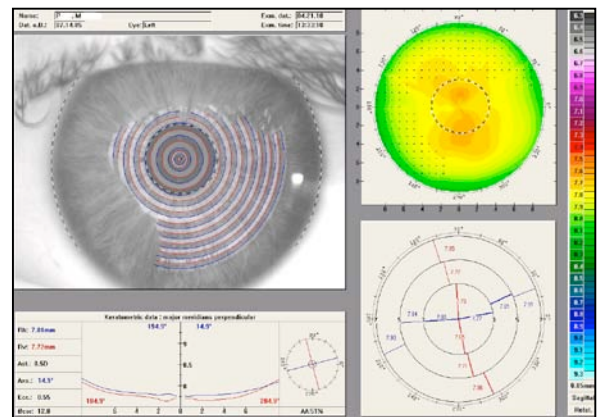
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	-0.75	0.00	0	20/10
OS	20/40	-1.00	0.00	0	20/15

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.86	7.76	0.54
OS	7.81	7.72	0.55

Visit 2: 04/22/2010 at 08:15am

After one night of wearing the contact lenses, P.M. complained about a slight feeling of pressure OS and the blurred vision OU while wearing the lenses. Subjective visual acuity was rated very good. There were no remarkable slit lamp findings.

Refraction:

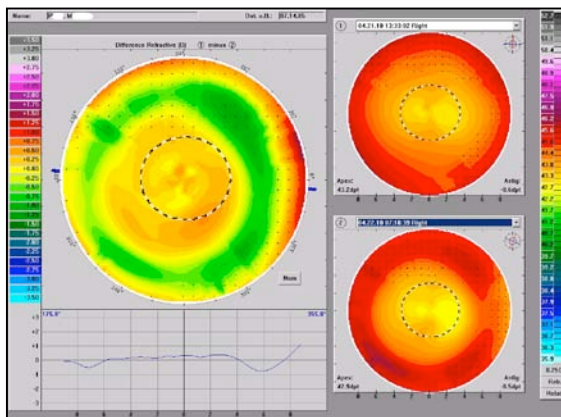
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.50	0.00	0	20/10
OS	20/15	-0.50	0.00	0	20/10

K – Readings:

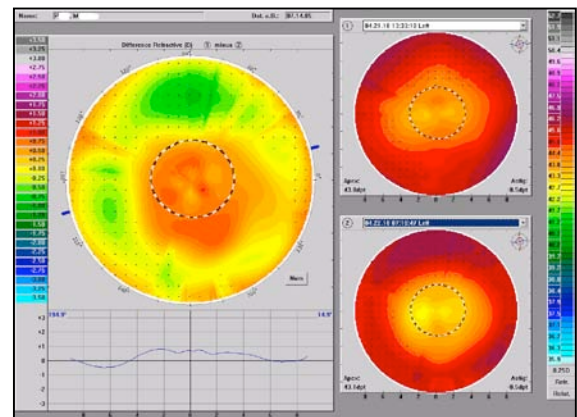
	horizontal (mm)	vertical (mm)	ecc.
OD	7.95	7.86	0.47
OS	7.88	7.79	0.47

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.32	+0.36
OS	+0.67	+0.71

Visit 3: 04/29/2010 at 8:00am

At the one week follow – up, P.M. was very happy with the comfort and visual outcome of his orthokeratology lenses. Slit lamp examination showed no abnormalities.

Refraction:

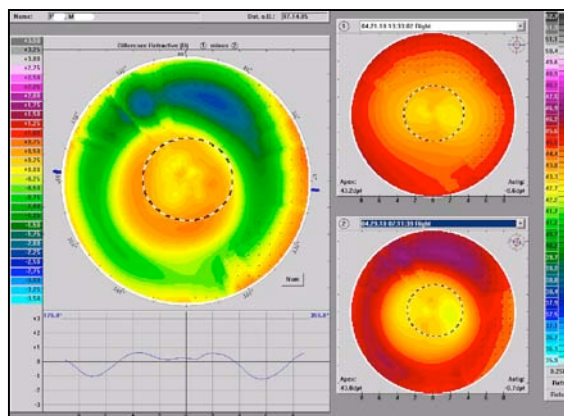
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/10	0.00	0.00	0	20/10
OS	20/12	-0.25	0.00	0	20/10

K – Readings:

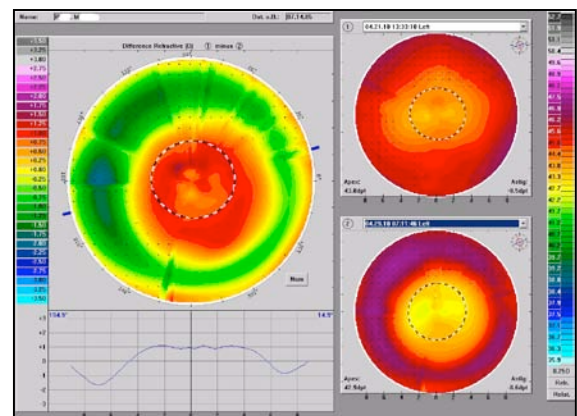
	horizontal (mm)	vertical (mm)	ecc.
OD	7.93	7.81	0.32
OS	7.98	7.87	-0.04

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.23	+0.24
OS	+0.90	+0.99

Visit 4: 06/08/2010 at 8:30am

After one month of orthokeratology lens wear, P.M. was very happy with the visual outcome and the overall lens comfort. The slit lamp findings were unremarkable.

Refraction:

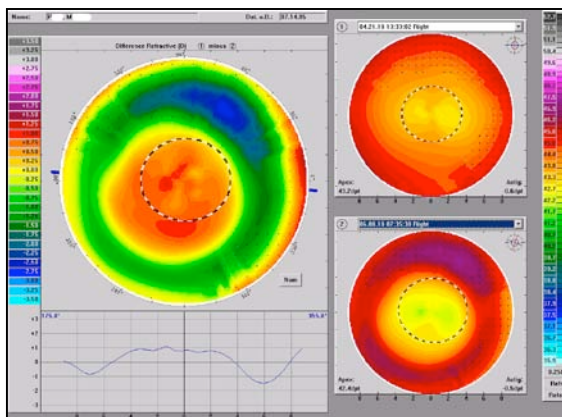
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/10	+0.25	0.00	0	20/10
OS	20/15	-0.25	0.00	0	20/10

K – Readings:

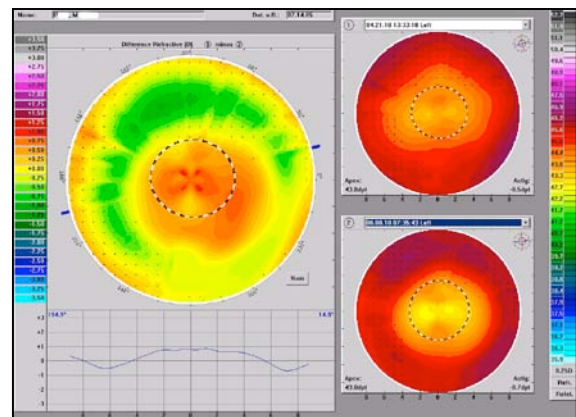
	horizontal (mm)	vertical (mm)	ecc.
OD	7.94	7.84	0.22
OS	7.90	7.78	0.45

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.85	+0.87
OS	+0.75	+0.81

Visit 5: 06/08/2010 at 5:30pm

At his final visit, P.M. was very content with the comfort and visual outcome of this contact lens wearing modality. He would like to continue wearing the lenses on a daily basis. His only complaint is he blurred vision through the -10.00 D lens.

Refraction:

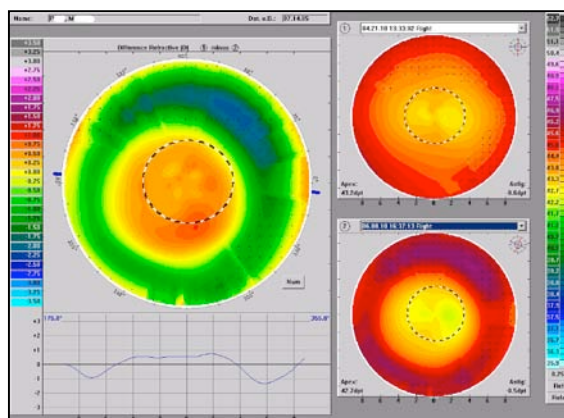
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/10	0.00	0.00	0	20/10
OS	20/12	-0.50	0.00	0	20/10

K – Readings

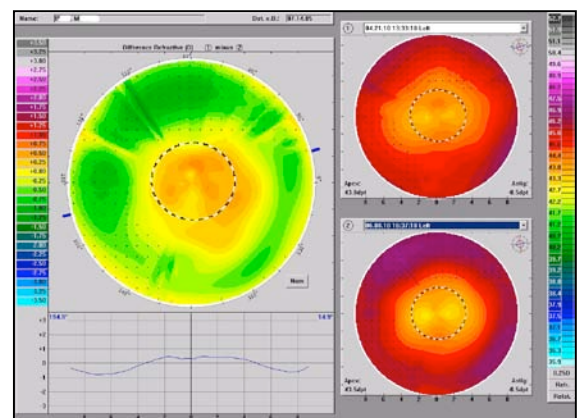
	horizontal (mm)	vertical (mm)	ecc.
OD	8.00	7.91	0.23
OS	7.80	7.71	0.43

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.52	+0.52
OS	+0.31	+0.28

4.6 S. K.

Visit 1: 05/05/2010 at 12:30pm

Patient History:

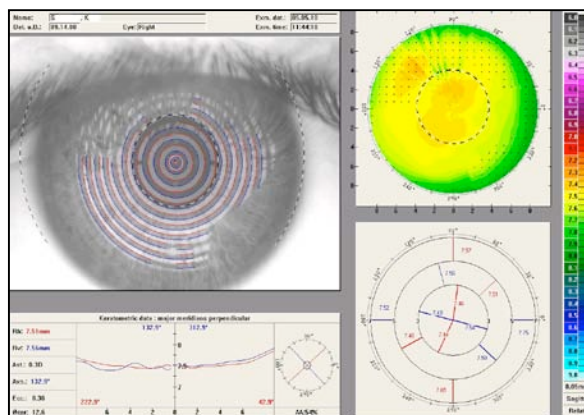
S.K. is a 21 year old white female student. She is not currently wearing any type of contact lens. Her ocular and systemic histories are unremarkable. She is not currently taking any medication and has no known allergies. Slit lamp examination showed no abnormalities.

Refraction:

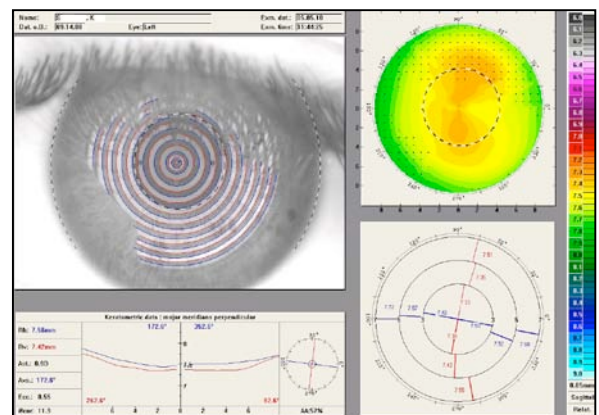
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/20	-0.50	-0.75	90	20/12
OS	20/15	-0.25	-0.75	60	20/12

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.51	7.56	0.36
OS	7.56	7.42	0.55

Visit 2: 05/06/2010 at 8:00am

S.K. wore the contact lenses for about eight hours the night before. She reported good lens comfort, but complained about blurred vision while wearing the contact lenses. There were no remarkable slit lamp findings.

Refraction:

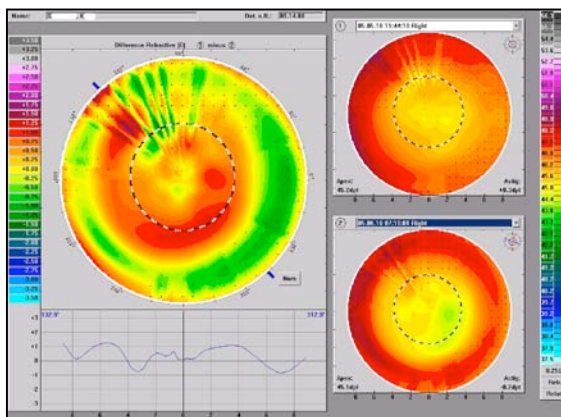
	uncorrected VA	sph (dpt)	cyl (dpt)	axis (°)	VA
OD	20/12	-0.00	-0.50	100	20/12
OS	20/12	-0.00	-0.50	65	20/10

K – Readings:

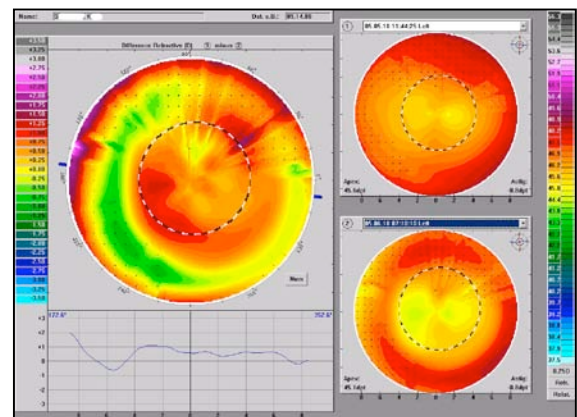
	horizontal (mm)	vertical (mm)	ecc.
OD	7.64	7.61	0.12
OS	7.63	7.49	0.46

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.05	+0.01
OS	+0.59	+0.55

Visit 3: 05/14/2010 at 9:00am

S.K. didn't wear her contact lenses for one night due to a amygdalitis. She complained about dry eyes in the morning. Slit lamp examination showed slight staining on the cornea OU.

Refraction:

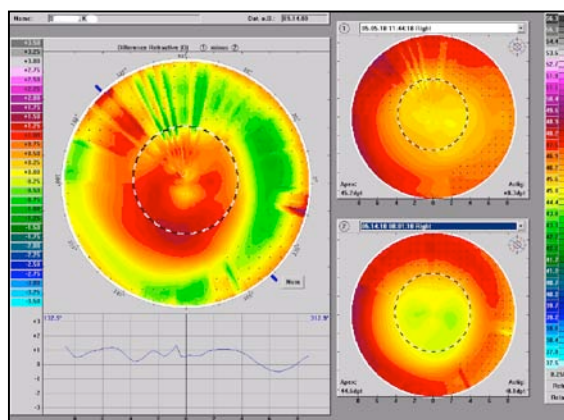
	uncorrected VA	sph (dpt)	cyl (dpt)	axis (°)	VA
OD	20/12	-0.25	-0.00	0	20/10
OS	20/12	-0.25	-0.00	0	20/12

K – Readings:

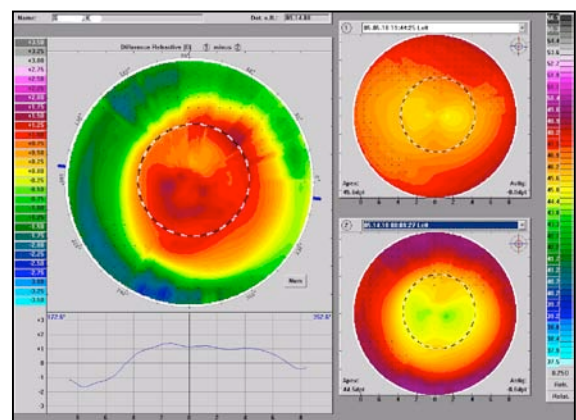
	horizontal (mm)	vertical (mm)	ecc.
OD	7.68	7.66	0.15
OS	7.65	7.54	-0.33

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.49	+0.46
OS	+1.14	+1.15

Visit 4: 06/07/2010 at 7:30am

After one month of orthokeratology contact lens wear, S.K. was very happy with the visual outcome and the lens comfort. Slit lamp examination showed no abnormalities.

Refraction:

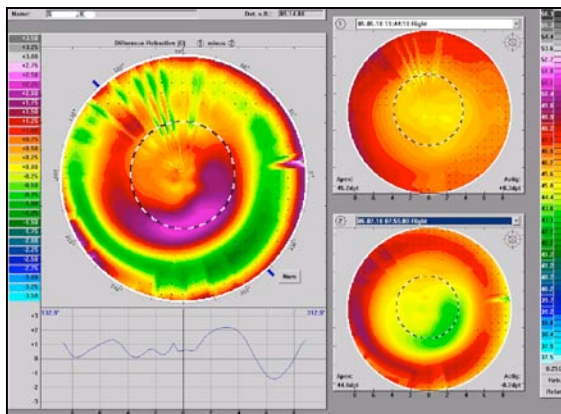
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.25	-0.00	0	20/10
OS	20/10	-0.25	-0.00	0	20/10

K – Readings:

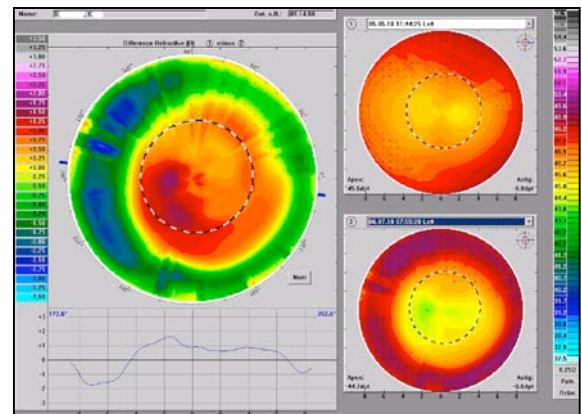
	horizontal (mm)	vertical (mm)	ecc.
OD	7.74	7.71	-0.16
OS	7.62	7.51	-0.33

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.63	+0.50
OS	+0.97	+0.95

Visit 5: 06/07/2010 at 5:00pm

Reviewing the past month of orthokeratology contact lens wear, S.K. was very happy with the visual outcome and the overall lens comfort. Her only complaint is the blurred vision while wearing the -10.00 D contact lenses. She would like to continue wearing the contact lenses on a daily basis.

Refraction:

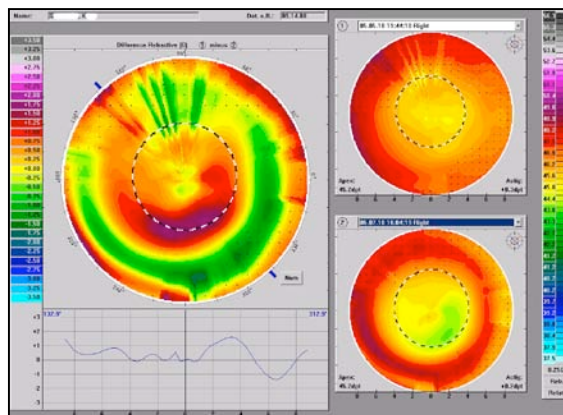
	uncorrected VA	sph (dpt)	cyl (dpt)	axis (°)	VA
OD	20/12	-0.25	-0.00	0	20/10
OS	20/10	-0.25	-0.00	0	20/10

K – Readings

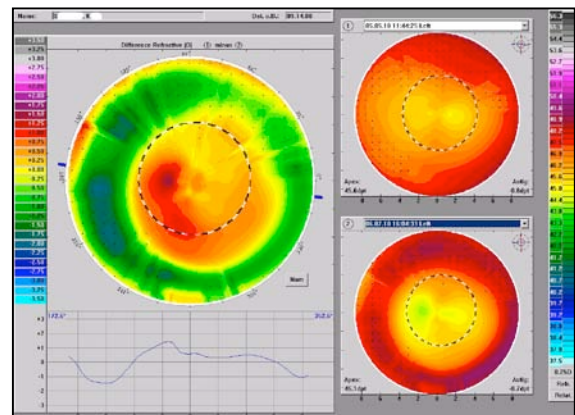
	horizontal (mm)	vertical (mm)	ecc.
OD	7.68	7.71	0.07
OS	7.56	7.45	0.04

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	-0.07	+0.05
OS	+0.61	+0.60

4.7 Sk. K.

Visit 1: 04/15/2010 at 3:00pm

Patient History:

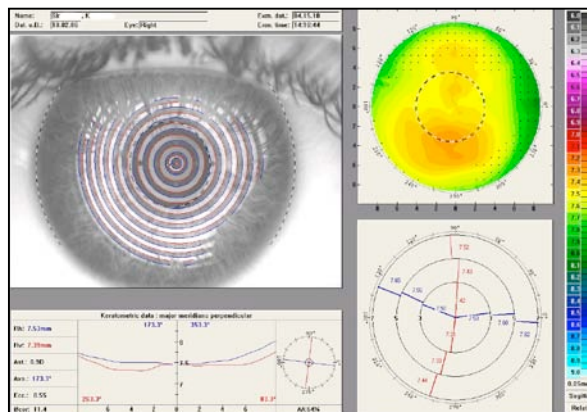
Sk.K. is a 23 year old white female student. She is currently wearing monthly disposable soft contact lenses. Her systemic and ocular histories are unremarkable and she is not currently taking any medication. She has no known allergies. Slit lamp examination showed no abnormalities.

Refraction:

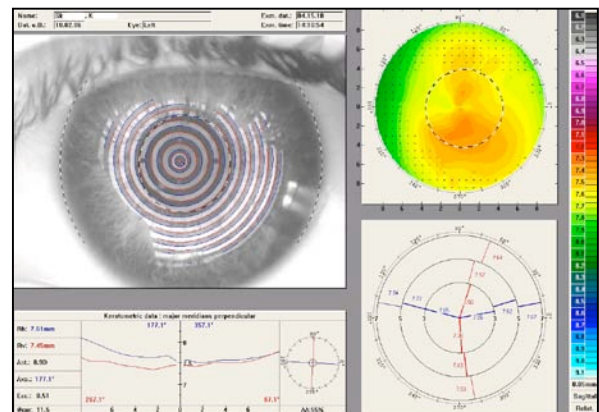
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/100	-1.00	-0.50	110	20/12
OS	20/40	-0.75	-0.25	5	20/12

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.53	7.39	0.55
OS	7.61	7.45	0.51

Visit 2: 04/22/2010 at 7:30am

After wearing the contact lenses for one night, Sk.K. had no complaints about lens comfort or visual acuity, but about the blurred vision through the -10.00 D lens. There were no remarkable slit lamp findings.

Refraction:

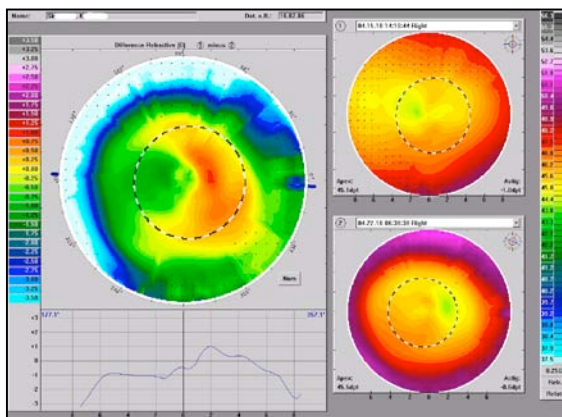
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	-0.75	0.00	0	20/20
OS	20/15	0.00	0.00	0	20/15

K – Readings:

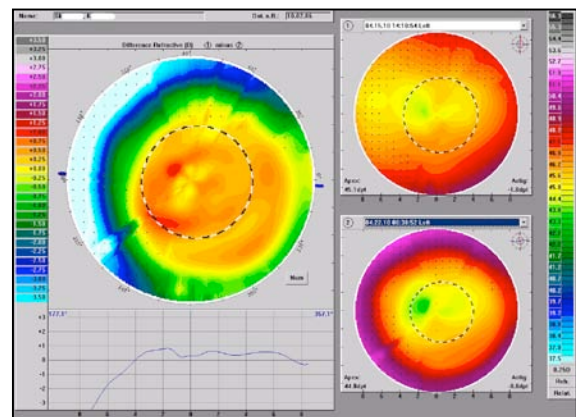
	horizontal (mm)	vertical (mm)	ecc.
OD	7.63	7.53	-0.37
OS	7.64	7.50	-0.21

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	-0.15	-0.05
OS	+0.59	+0.27

Visit 3: 04/29/2010 at 7:45am

Sk.K. reported good overall lens comfort and very good subjective visual acuity. There were no remarkable slit lamp findings.

Refraction:

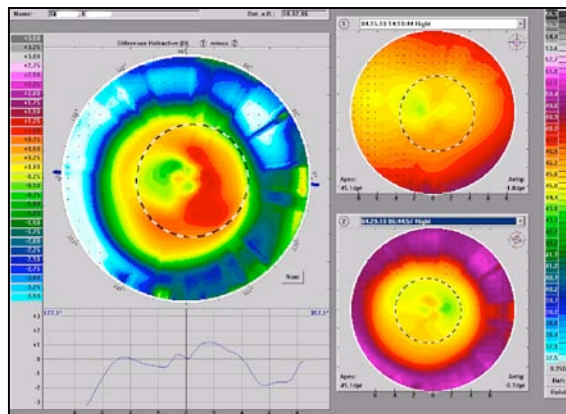
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/15	+0.25	-0.50	137	20/15
OS	20/15	+0.50	-0.50	178	20/15

K – Readings:

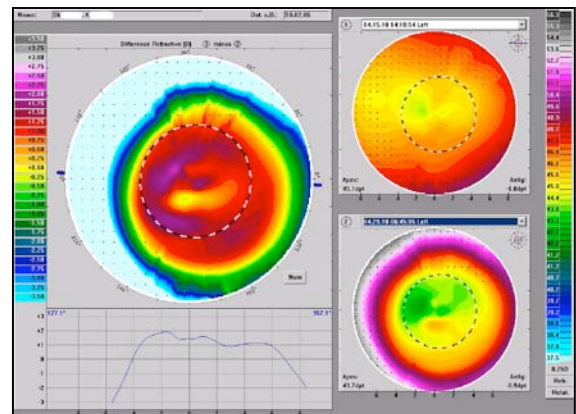
	horizontal (mm)	vertical (mm)	ecc.
OD	7.70	7.58	-0.57
OS	7.75	7.60	-0.84

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.74	+0.76
OS	+1.68	+1.34

Visit 4: 06/04/2010 at 7:30am

Sk.K. was wearing the lenses every night for six weeks and is very happy with the visual outcome and lens comfort. Slit lamp examination showed grade 2 staining on the temporal cornea OD.

Refraction:

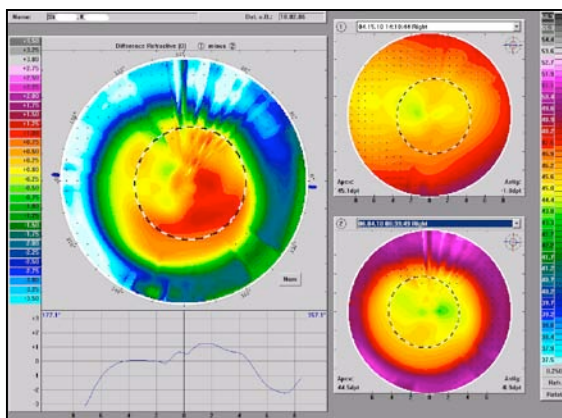
	uncorrected VA	sph (dpt)	cyl (dpt)	axis (°)	VA
OD	20/20	0.00	-0.50	155	20/12
OS	20/15	+0.50	-0.50	170	20/12

K – Readings:

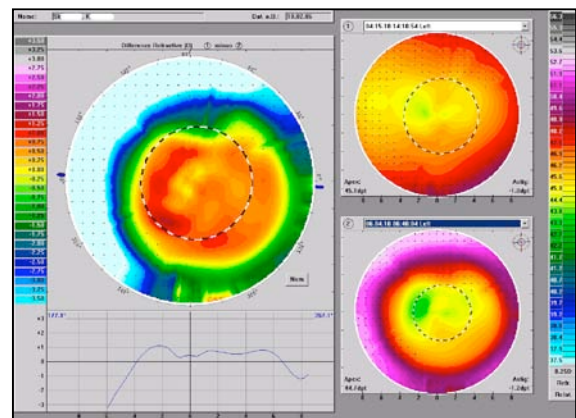
	horizontal (mm)	vertical (mm)	ecc.
OD	7.69	7.54	-0.64
OS	7.65	7.44	-0.65

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.98	+0.58
OS	+0.57	+0.37

Visit 5: 06/04/2010 at 7:00pm

Sk.K. would like to continue wearing the contact lenses on a daily basis. She is very happy with the visual outcome and the overall lens comfort but she would feel more comfortable with a lower powered lens.

Refraction:

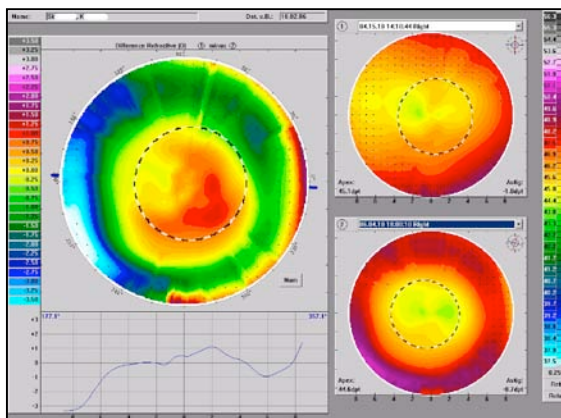
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	0.00	-0.50	155	20/12
OS	20/12	+0.50	-0.50	170	20/12

K – Readings

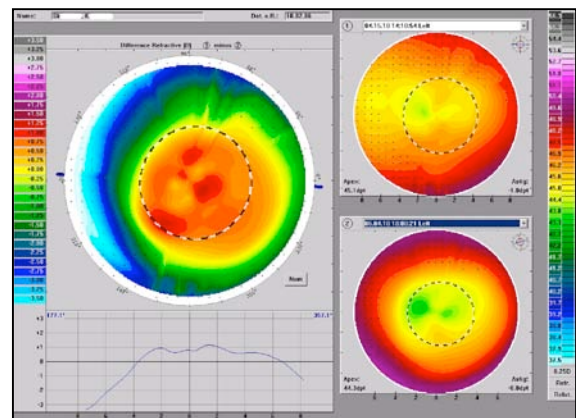
	horizontal (mm)	vertical (mm)	ecc.
OD	7.64	7.52	-0.09
OS	7.64	7.50	-0.45

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.83	+0.74
OS	+0.98	+0.75

4.8 V. B. K.

Visit 1: 04/07/2010 at 1:45pm

Patient History:

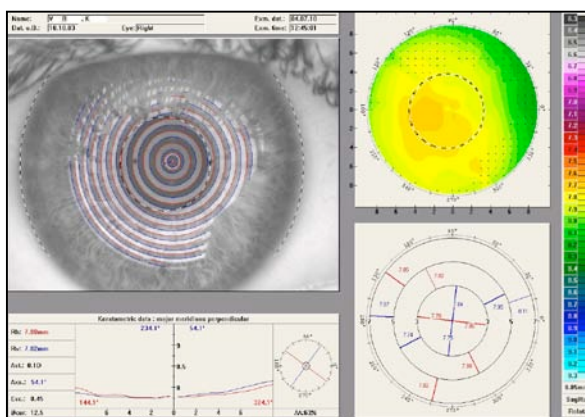
V.B.K is a 26 year old white female student with unremarkable systemic and ocular histories. She is currently not wearing any type of contact lens and is not taking any medication. She has no known allergies.

Refraction:

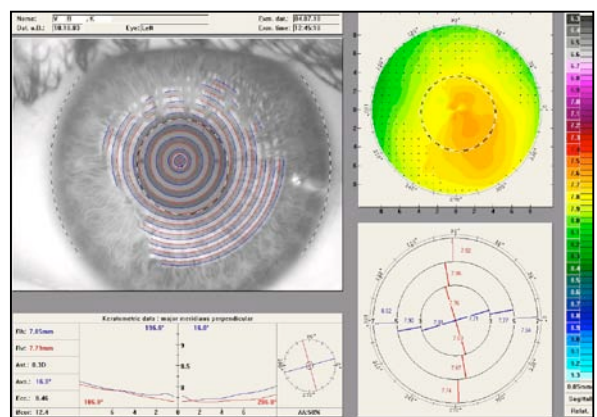
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/15	-0.75	0.00	0	20/15
OS	20/20	-0.25	-0.75	7	20/15

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.80	7.82	0.45
OS	7.85	7.79	0.46

Visit 2: 04/08/2010 at 8:00am

After the first night of contact lens wear, v.B.K had difficulty removing the lenses in the morning and complained about dry eyes after lens removal and blurred vision while wearing the lenses. She was wearing the lenses for about 4,5 hours the last night. Slit lamp examination showed grade 2 staining on the inferior limbus OS.

Refraction:

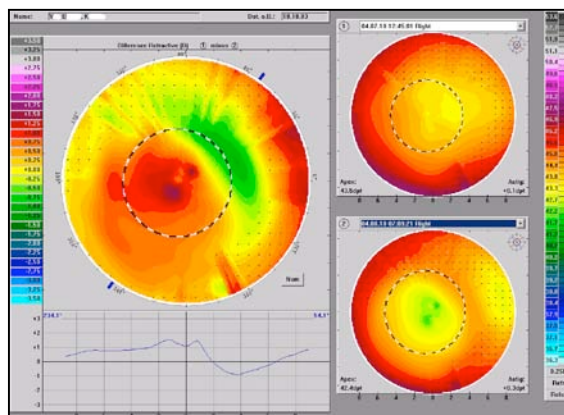
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	+0.50	-0.25	167	20/12
OS	20/12	+0.50	-0.50	22	20/12

K – Readings:

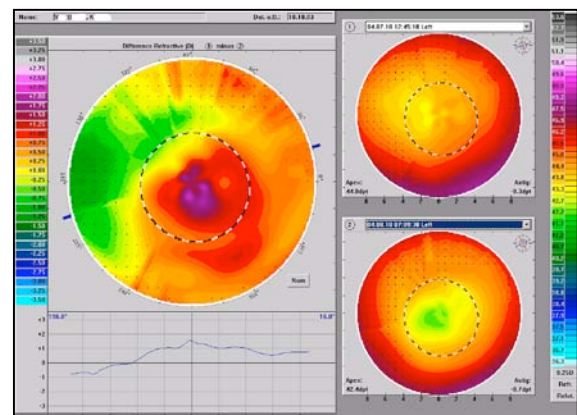
	horizontal (mm)	vertical (mm)	ecc.
OD	7.84	7.90	0.41
OS	7.93	7.80	0.27

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+0.96	+1.03
OS	+1.49	+1.45

Visit 3: 04/15/2010 at 11:00am

From visit 2 to visit 3, v.B.K was not wearing the contact lenses for one night. She still had difficulty removing the lenses in the morning and she complained about ghosting at night. She was usually wearing the lenses five to seven hours a night. Slit lamp examination showed no abnormalities.

Refraction:

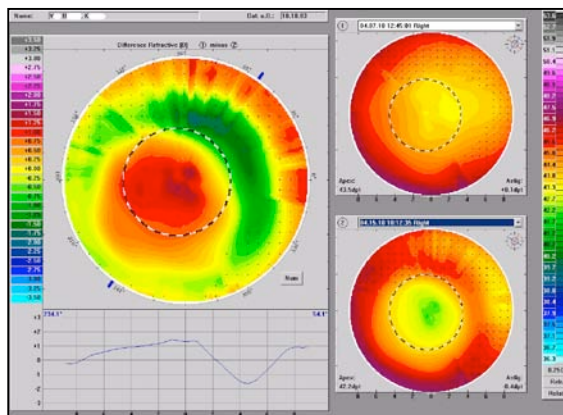
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/15	+1.00	-0.50	143	20/12
OS	20/20	+1.25	-0.75	3	20/12

K – Readings:

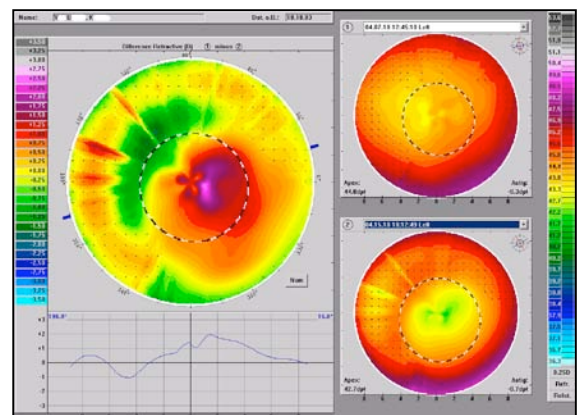
	horizontal (mm)	vertical (mm)	ecc.
OD	7.84	7.77	0.20
OS	7.92	7.79	0.29

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.36	+1.28
OS	+1.24	+1.51

Visit 4: 05/06/2010 at 10:30am

V.B.K did not wear the contact lenses for three nights in the past three weeks. In addition, she slept for only five hours each night. She still had problems with the removal of the lenses and complained about bad subjective visual acuity and ghosting at night. There were no remarkable slit lamp findings.

Refraction:

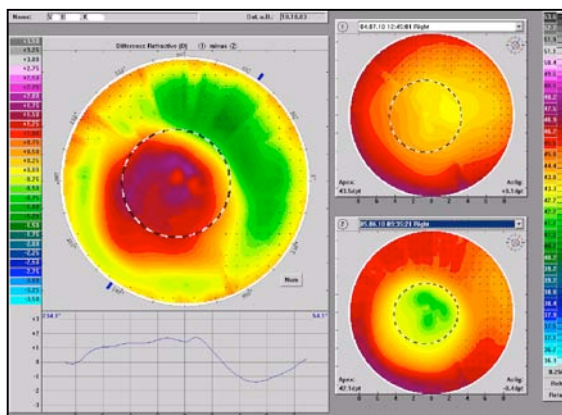
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/20	+0.75	-0.25	168	20/12
OS	20/30	+1.50	-0.75	168	20/15

K – Readings:

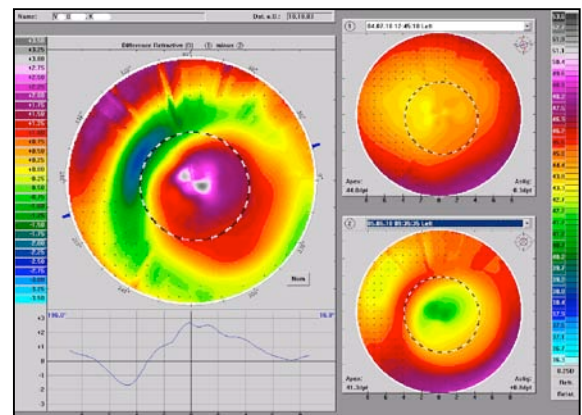
	horizontal (mm)	vertical (mm)	ecc.
OD	7.97	7.89	0.19
OS	7.71	7.86	0.30

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.47	+1.30
OS	+2.73	+2.54

Visit 5: 05/06/2010 at 5:45pm

V.B.K would not continue wearing the contact lenses due to insufficient visual acuity. She felt very uncomfortable with the -10.00 D lenses.

Refraction:

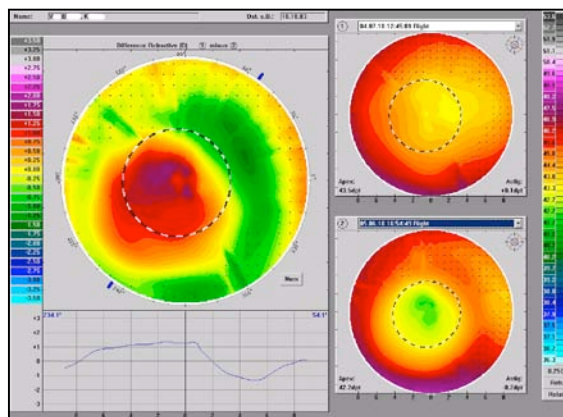
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/20	+0.25	-0.50	145	20/12
OS	20/25	+1.25	-0.75	0	20/12

K – Readings

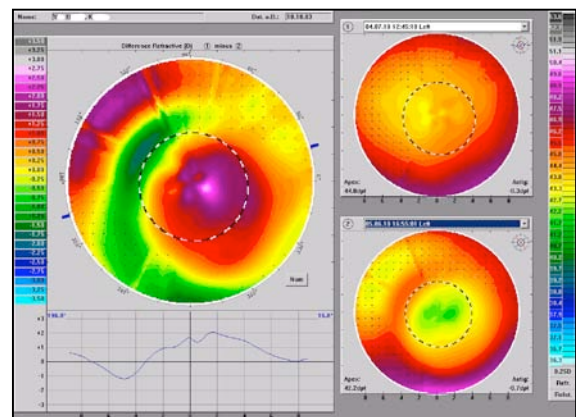
	horizontal (mm)	vertical (mm)	ecc.
OD	7.89	7.86	0.18
OS	7.88	7.75	0.16

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.16	+1.23
OS	+1.78	+1.71

4.9 T. H.

Visit 1: 03/31/2010 at 1:30pm

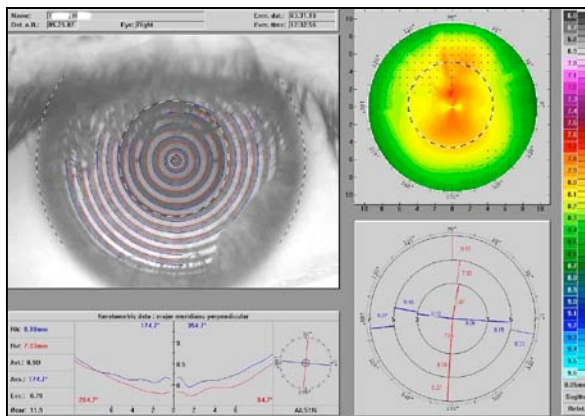
T.H. is a 22 year old white femal student with unremarkable systemic and ocular histories. She is not currently wearing any type of contact lens and is not taking any medication. She has no known allergies. Slit lamp findings were unremarkable.

Refraction:

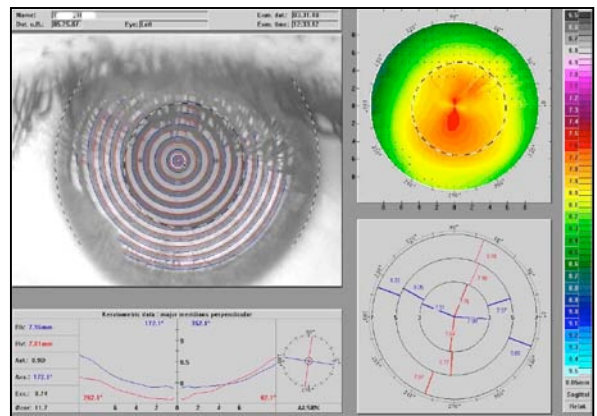
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/60	-0.75	-1.00	170	20/15
OS	20/25	-0.25	-0.75	0	20/15

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	8.10	7.93	0.70
OS	7.96	7.81	0.74

Visit 2: 04/30/2010 at 9:00am

T.H. wore the contact lenses for about nine hours the night before. Slit lamp examination with fluorescein showed a slight contact lens imprint on the sclera OD and the tearfilm break up time was at about two seconds OU.

Refraction:

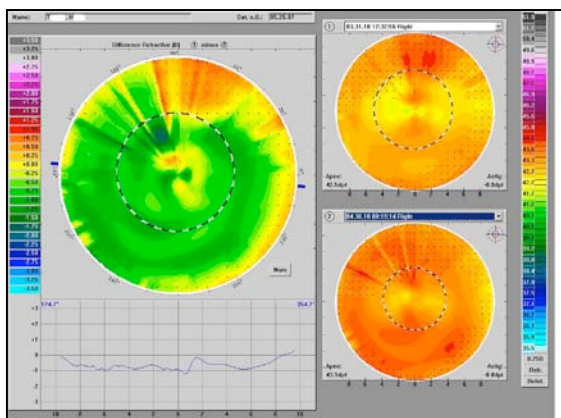
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/50	-0.50	-0.50	180	20/15
OS	20/25	0.00	0.00	0	20/25

K – Readings:

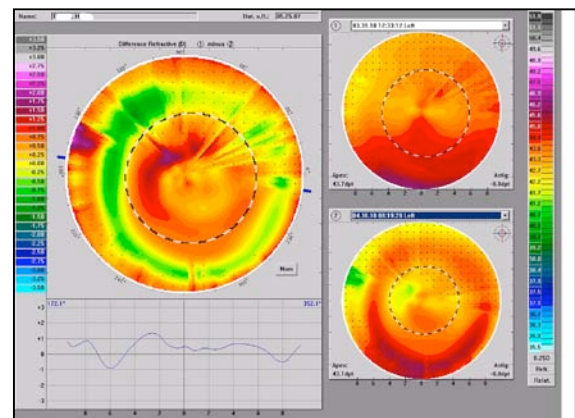
	horizontal (mm)	vertical (mm)	ecc.
OD	8.00	7.86	0.76
OS	8.08	7.93	0.66

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	-0.57	-0.96
OS	+0.52	+0.54

Visit 3: 05/07/2010 at 10:00am

After one week of overnight lens wear, T.H. complained about reduced subjective visual acuity. Slit lamp examination showed no abnormalities.

Refraction:

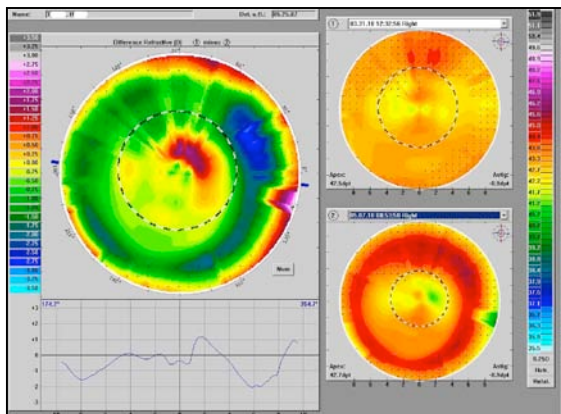
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/30	-0.50	-0.50	6	20/15
OS	20/15	+0.25	-0.25	120	20/15

K – Readings:

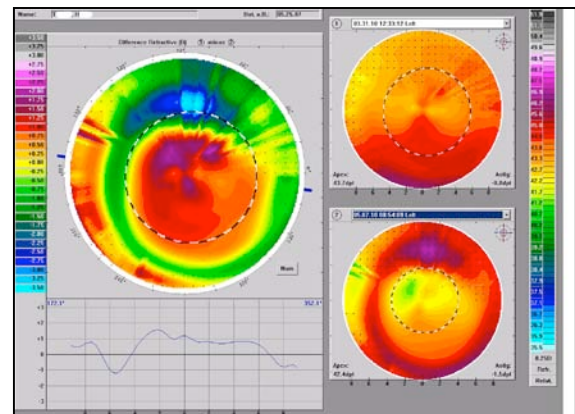
	horizontal (mm)	vertical (mm)	ecc.
OD	8.13	7.96	0.65
OS	8.04	7.76	0.54

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	-0.37	-0.39
OS	+1.58	+1.23

T.H. discontinued wearing the contact lenses after about two weeks due to poor subjective visual acuity.

4.10 Y. G.

Visit 1: 05/20/2010 at 4:00pm

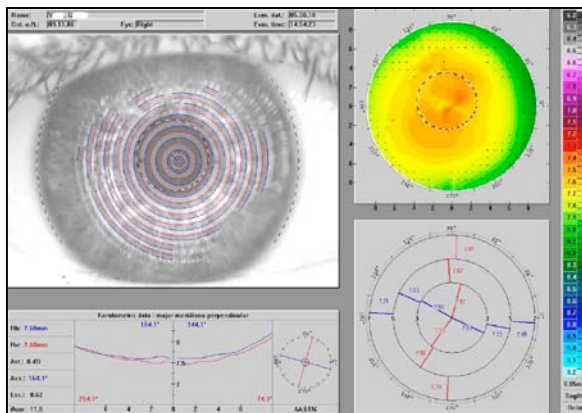
Y.G. is a 23 year old white female student. She is not currently wearing any type of contact lens. She has unremarkable systemic and ocular histories and no known allergies. She is currently not taking any medication.

Refraction:

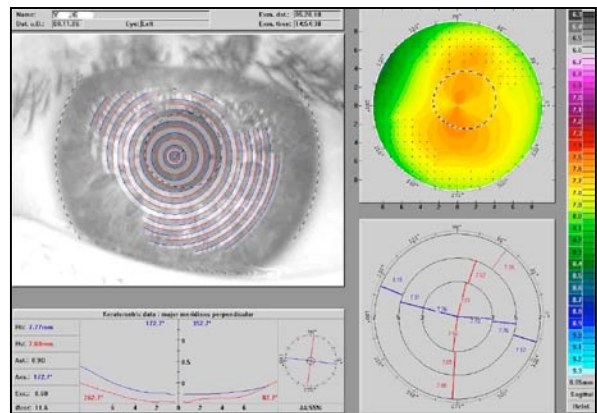
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/12	-0.50	0.00	0	20/12
OS	20/12	-0.50	-0.25	170	20/12

Topography:

OD:



OS:



K – Readings:

	horizontal (mm)	vertical (mm)	ecc.
OD	7.68	7.60	0.62
OS	7.77	7.60	0.60

Visit 2: 06/04/2010 at 10:00am

After one night of contact lens wear, Y.G. complained about a strong foreign body sensation on OU with her contact lenses. There were no remarkable slit lamp findings.

Refraction:

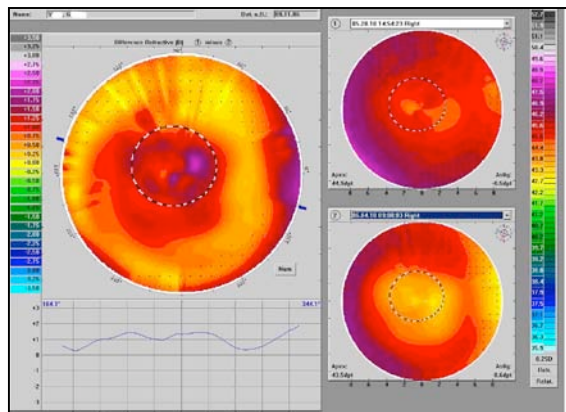
	uncorrected VA	sph (D)	cyl (D)	axis (°)	VA
OD	20/10	+0.25	0.00	0	20/10
OS	20/12	+0.25	-0.75	164	20/10

K – Readings:

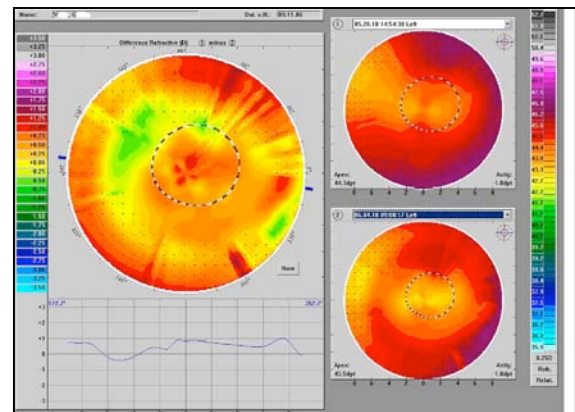
	horizontal (mm)	vertical (mm)	ecc.
OD	7.80	7.69	0.49
OS	7.85	7.68	0.67

Refractive Compare:

OD:



OS:



Apical Power Change:

	Center of the Pupil (D)	Center of the Cornea (D)
OD	+1.06	+1.44
OS	+0.82	+0.83

Y.G. discontinued wearing the contact lenses after three nights due to a strong foreign body sensation OU.

4.11 Summary

Eight out of ten subjects finished the study, six female and two male. The the mean age of the subjects was 23.9 years. Included in this summary are only the eight subjects who finished the study. The following table compares the data of the baseline measurement to the data of the morning measurement after four weeks of contact lens wear.

	Maximum	Minimum	Arithmetic mean
Subjective Refraction Change Sphere	+1.75 D	0.00 D	+1.00 D
Subjective Refraction Change Cylinder	+0.75 D	+0.25 D	+0.22 D
Apical Power Change	2.73 D	0.04 D	1.11 D
K – Reading Change horizontal	0.23 mm flatter	0.14 mm steeper	0.09 mm flatter
K – Reading Changes vertical	0.27 mm flatter	0.01 mm steeper	0.12 mm flatter
Eccentricity Change	1.19 lower	0.16 lower	0.65 lower

Table 2: Summary Results

5 Discussion

5.1 Contact Lens Comfort

In this study, the contact lens comfort of the everted lenses was rated good by most of the subjects. These findings are similar to the study about lens comfort of everted soft contact lenses at Pacific University in 2005. Only three out of ten subjects complained about a strong foreign body sensation the first night of lens wear. One of those three subjects discontinued wearing the lenses due to the high discomfort. The other two subjects adapted to the lens during the first week of lens wear and there were no further complaints about lens comfort. All of the subjects who complained about lens discomfort did not wear any type of contact lens on a regularly basis before. This could be a reason for the discomfort in the first few nights of lens wear.

There was a second aspect of lens discomfort that all of the subjects in this study complained about: the -10.00 D contact lens. This high powered lens creates a high amount of blur for a person with a refractive error of -0.50 to -1.00 D. The insertion and removal of the contact lens becomes more difficult and it is not possible to read or watch TV while wearing the contact lenses at night. All of the subjects would have preferred a lower powered contact lens, so that they can see more than just shapes while wearing the lenses.

5.2 Corneal Flattening

Some of the subjects showed a slight steepening of the central apical power in one eye after the first night. The mean flattening after the first night was about 0.40 D. That is about one quarter of what Caroline and Andre found in 2005 after 10 hours of overnight wear.

The greatest changes in corneal topography happened during the first week of contact lens wear. Compared to the baseline measurement, the mean flattening was about 0.94 D. This is about two thirds of what Caroline and Andre found in 2005.

The mean flattening after four weeks of contact lens wear reached about 1.00 D. Compared to the findings in 2005, this is less than a third.

The topographical outcome in this study ranged from about 0.50 D to 2.50 D of corneal flattening, which is +0.75 D more compared to the conclusions that Caroline and Andre stated in 2010. The changes in the subjective refraction ranged from plano to +1.75 D. The difference in the values could be due to accommodation during the subjective refraction or due to a decentered treatment zone.

The eccentricity changes ranged from 0.1 to 1.19 of corneal flattening with the lowest eccentricity at -0.65 and the highest eccentricity at 0.45 after four weeks of orthokeratology treatment. The mean eccentricity change was 0.65.

At closer observation of the results of some of the subjects, the comparison of visit 3 and visit 4 showed that the flattening slightly decreased. This was probably due to the high contact lens power. A -9.50 D contact lens could have been a solution for this problem.

Regarding

Point 5 of the conclusions of Caroline and Andre can be absolutely confirmed based on the results of this study. The topographical changes could not be predicted in advance and varied from subject to subject.

5.3 Problems

Unlike the conclusions of Caroline and Andre, the zone of central corneal steepening was not the number one complication in this study. Rather, the decentration of the contact lens and the resultant cylinder were a considerable problem. In addition, some of the subjects complained about ghosting at night that could be due to this resultant cylinder or the de-centered treatment zone.

The number one complaint however in this study was the high – minus – power of the contact lenses used. All of the subjects felt very uncomfortable with the dramatically reduced visual acuity during lens wear.

6 Conclusion

As it is stated and proven in previous studies, the results of this study show that everted silicone hydrogel lens wear leads to orthokeratology – such as effects on the cornea and in the refractive error. Although most of the subjects in this study were content with the overall lens comfort and visual outcome, there are certainly continuative studies that could be accomplished to optimize the effects.

The main subject complaint throughout the whole study was the high power of the contact lens used and the resulting blurred vision during lens wear. A silicone hydrogel lens with plano power and the same effect would be a tremendous advance regarding the visual aspect of contact lens comfort. In addition to this, a special lens design that makes the refractive change more predictable would contribute to the subject's satisfaction in visual outcome. The decentration problem could be solved by a larger contact lens diameter to keep the lens centered on the cornea.

As there were some complaints about ghosting at night, additional studies regarding the diameter of the treatment zone and contrast sensitivity measurements would give information about the degree of disturbance and could possibly lead to an answer. Measurements with a wave front analyzer could evaluate the changes in refractive error more precisely. The comparison with the apical power change measurement of the keratographer would certainly give some interesting information and show a coherence, whereas the changes in the subjective refraction are definitely more important to the subjects.

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Author's Declaration

I hereby declare, that this thesis is my own work, which was written without unauthorized assistance. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Place, Date

Signature