Case Report: Two

The Correction of Astigmatism with a Rigid Gas Permeable Contact Lens

By

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ABSTRACT: This report details the prescribing of a rigid gas permeable bitoric contact lens on a patient with significant corneal astigmatism. Possible treatment options, and the benefits and disadvantages of each, are explored. Further, this report discusses rigid gas permeable toric lenses in depth.

Note to the Diplomate candidate

This is an example case report only. It is important for the candidate to demonstrate his or her knowledge in the area under consideration. It should be noted that diagrams, charts, and photographs are optional and often add significantly to the report. Although references are not found in this example, they are recommended. The goal is to be thorough and complete, not to write a book chapter.

The Correction of Astigmatism with a Rigid Gas Permeable Contact Lens

Patients often present with significant astigmatic errors for which toric correction is indicated. Further, many of these patients have significant corneal toricity for which a Rigid Gas Permeable (GP) iso-curve base lens, either spherical or aspherical, is inappropriate due to poor geometric alignment. For these patients, an GP toric lens is often the best treatment option. This case report details one such case.

CASE PRESENTATION

J.N., then a twenty-five-year-old, white, male, professional musician, presented on October 4, 1999 at 2:00 pm as a new patient upon referral from his doctor in New York City. His Chief Complaint was a two-month history of increasing lens intolerance accompanied by redness. His last ocular examination had been five months prior to his presentation.

The History of Present Illness included a thirteen-year history of GP lens wear, worn on a daily wear basis. His current lenses were eight-years-old, and, at the time of his presentation, he had worn them for four hours. His habitual wearing time was twelve hours. He used the Boston™ Original Care system on a daily basis. He could not remember the last time he replaced his lens case. The onset of his symptoms was gradual, and the frequency had become constant. The severity was reported to be moderate, and the only remitting factor was lens discontinuation. He denied any self treatment or other prescribed treatment.

His Past Ocular History was unremarkable, except for significant myopia and astigmatism. He reported wearing spectacle correction since age seven. He did not present with his habitual spectacles, and he claimed to wear them only rarely "around the house." J.N. reported that the spectacles were "several" years old. He denied any previous injury, surgery, or significant disease in either eye. His last previous dilated fundus examination had been one year prior to his presentation.

His Past Medical History was wholly unremarkable and noncontributory. He reported a history of headaches that resolved prior to his presentation. He reported taking no medications, and he denied any general or medication allergies. His Social History defined him as a non-smoker, and light social drinker. He played the Oboe in a major symphony orchestra. He was married with one young daughter. His Family History was significant for hypertension, heart disease, cancer, and Type II diabetes.

EXAMINATION FINDINGS

Distance Acuity with Habitual GP Lenses:

OU	**20 / 20**	**Stable**
OD	**20 / 25**	**Variable**
OS	**20 / 20 -1**	**Stable**

Sphero-Cylinder Over-Refraction:

OD	**Plano**	**Sphere**			**20 / 20**	**Stable**
OS	**+ 1.00**	**- 1.00**	**X**	**145**	**20 / 20**	**Stable**

Over-Keratometry:

OD	**47.00**	**/**	**47.00**	**@**	**000**
OS	**46.00**	**/**	**48.00**	**@**	**065**

J.N.'s lenses both decentered inferiorly 1.25 mm in primary gaze. Both lenses moved 1.50 mm and lagged rapidly inferiorly by the same amount. The fluorescein patterns in centered position demonstrated significant toricity, as evidenced by the horizontal "dumbbell" pattern observed. There was moderate apical bearing centrally, with continued bearing across the horizontal meridian, and progressively increasing clearance noted along the vertical meridian. No edge lift was noted in either eye. However, there was inferior bubbling observed about fifty percent of the time after the blink in the left eye.

Pupillary Function, Confrontation Fields, Extra-Ocular Muscle Function, Near Point of Convergence, Accommodative Amplitude, Vergence Testing, Color Vision Testing, and Stereo Acuity were all "Within Normal Limits."

Habitual GP Lens Parameters:

Lens Parameter	OD	OS
Overall Lens Diameter:	9.50 mm	9.50 mm
Posterior Optic Zone Diameter:	7.80 mm	7.80 mm
Base Curve Radius:	7.71 mm	7.71 mm
Back Vertex Drum Power:	- 4.25 D	- 3.00 D
Anterior Optic Zone Diameter:	8.20 mm	8.20 mm
Center Thickness:	0.12 mm	0.13 mm
Edge Thickness:	Not Measured	Not Measured
Secondary Curve Radius:	Not Measured	Not Measured
Tertiary Curve Radius and Width:	Not Measured	Not Measured
Quaternary Curve Radius and Width:	Not Measured	Not Measured
Prism:	None	None
Blend:	Moderate	Moderate
Lens Material: (By Report)	Boston IV™	Boston IV™
Lens Color:	Blue	Blue

Manifest Refraction:

OD	- 4.50	- 2.75	X	007	20 / 20
OS	- 3.00	- 5.00	X	161	20 / 20

Keratometry:

OD	43.50	/	46.25	@	100	No Distortion
OS	43.50	/	47.75	@	070	No Distortion

Goldmann Applanation Tonometry:

OD 11 mmHg @ 2:43 pm

OS 11 mmHg

Ultrasonic Corneal Pachymetry:

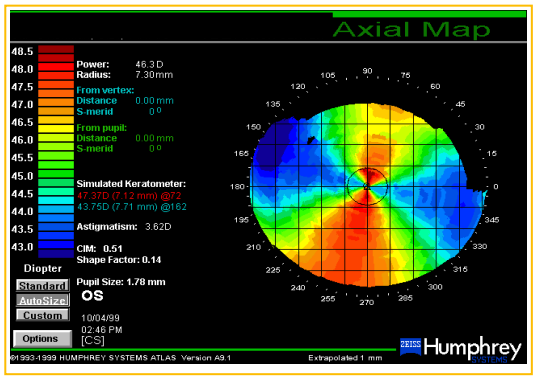
OD 509 µM

OS 506 µM

Zeiss Humphrey Atlas™ Simulated Keratometry Measurements:

OD	43.75	/	46.12	@	106	CIM: 0.43
OS	43.50	/	47.75	@	070	CIM: 0.51

The "Corneal Irregularity Measurement" (CIM) is a measure on the Atlas™ of the departure of the cornea from the "best fit toric curve." This departure describes the irregularity of the cornea. Normal values for the CIM range between 0.03 and 0.68. Numbers above 0.68 are considered borderline, above 0.85 is abnormal. J.N.'s "Axial Maps" demonstrated an asymmetric "bowtie" configuration in the right eye and left eye.



Horizontal Visible Iris Diameter:

OD	11.50 mm
OS	11.50 mm

Vertical Visible Aperture:

OD	9.00 mm
OS	9.00 mm

Pupillary Diameter:

OD	3.50 mm (Photopic)	5.50 mm (Scotopic)
OS	3.50 mm (Photopic)	5.50 mm (Scotopic)

The upper lids are 2.50 mm central to the limbus, and the lower lids are right at the limbus.

Anterior Segment Evaluation

A thorough slit lamp examination revealed lids that were well apposed to the globes and were without observable defect or disease. The tarsal conjunctivae were remarkably smooth for a contact lens wearer, and there was no vascular injection noted. The bulbar conjunctivae were similarly quiet, with the exception an inferior arcuate fluorescein staining pattern observed in the inferior limbal sulcus of each eye. This staining represented a mechanical injury from the lens edge due to the inferior lens positioning. Otherwise, the bulbar conjunctivae were unremarkable.

The cornea in each eye was clear and free of defect. No staining was observed. The iris in each eye was brown in color, flat, and without defect. The anterior chamber angle was Grade IV in each eye, and each chamber was clear.

Posterior Segment Evaluation

A binocular indirect dilated fundus examination through a + 20 D lens revealed wholly normal posterior segments that were noncontributory to this case. The cup-to-disc ratios were 0.2 / 0.2 in each eye, and the artery-to-vein ratios were 1:2 in each eye.

Clinical Assessment

The clinical assessment of this patient included significant myopia, more in the right eye than the left; and significant corneal astigmatism, more in the left eye than the right. Though this author could not be certain without prior records, it was believed that J.N.'s refractive status was relatively stable. Except for the mechanical injury from the lenses, both eyes were very healthy.

J.N.'s right eye was fully corrected by his current GP contact lens. However, the lens alignment was poor due to the spherical iso-curve base on a significantly toric corneal surface, resulting in poor lens positioning and physiology. The left lens was similarly poorly aligned. In addition, the left lens flexed on the eye, as evidenced by the nonspherical over-keratometry, and there was residual astigmatism noted in the over-refraction that could not be accounted for by the over-keratometry.

It should be noted that the over-keratometry was not entirely consistent with the over-refraction, the manifest refraction, and the keratometry readings for the left eye. One must explain this discrepancy. The most likely explanation is found in the variable acuity through the left lens. The variability indicates that the flexure was not constant.

Toric correction of some kind was indicated to correct the patient's Chief Complaint. The treatment options included doing nothing, discontinuation of

contact lens wear followed by either spectacle or surgical correction, hydrogel toric lens correction, or toric rigid lens correction.

Doing nothing was not a good option. The current lenses were positioning poorly resulting in an injury that led to the patient's complaint of lens intolerance. Discontinuation of lens wear followed by either spectacle or surgical corrections were both viable options, both of which could have resulted in quality visual acuity. However, the spectacle lens option had the disadvantage of a loss of "functional normalcy" provided by contact lenses.

When discussed with the patient, J.N. desired neither to discontinue contact lens wear nor to contemplate a refractive surgery option. Therefore, after a discussion of these options, they were discounted.

The remaining options of hydrogel toric lenses and GP torics were then considered. Hydrogel toric lenses would be comfortable, if not more comfortable than the GP option. However, the acuity through this option, while good, would not be as clear or stable as the GP option. Further, none of the hydrogel torics available in J.N.'s powers had an oxygen transmissibility (dK/t) that equaled the GP lens materials. Therefore, the lenses would not be as physiologically desirable as the GP options. Further, hydrogel lenses are more prone to protein deposition, and they need more frequent replacement which increases the cost relative to the cost of the GP lens option amortized over the prospective life-span

of the GP lenses. After a complete discussion of his options, J.N. decided to go with GP toric lenses.

The realities of lid / lens interaction makes a GP lens position and move the best when the lens aligns horizontally, but has a slight clearance vertically. This alignment is essentially what one finds when one places a spherical iso-curve base curve on a cornea with 0.75 Diopters of "with-the-rule" astigmatism. Therefore, one should strive for that "low toric simulation." The horizontal meridian should be aligned and the vertical meridian should be flatter than a proper alignment by approximately 0.75 Diopters.

Many of the theories about prescribing toric lenses revolve around being aligned in the "flatter" meridian and flatter than aligned in the "steep" meridian. These theories include several simplified guides to toric GP prescribing, including the best known of these guides, the Mandell-Moore Guide. These guides are adequate when dealing with a "with-the-rule" cornea. However, when dealing with an "against-the-rule" cornea, if one follows the Mandell-Moore guide, then one creates a lens that allows the lens to move laterally and that resists vertical movement.

This situation would result in a lens alignment that would be poor, with poor lens comfort and acuity. This situation is why there is a fundamental flaw in designing toric lenses in this manner. For that reason, this author created a toric lens guide

based on the Mandell-Moore guide that uses fit factors applied to the horizontal and vertical meridians instead of the flat and steep meridians. This guide was used to design lenses for this patient. (See Appendix)

The guide enabled the practitioner to select the two principal base curve radii properly to create the with-the-rule low toric simulation, and to keep track of the powers in each meridian without having to resort to the use of an optical cross.

There are three types of toric GP lens designs—the front toric, the back (base) toric, and the bitoric. Further, there are three different types of bitoric lenses—the Spherical Power Effect (SPE), the Cylinder Power Effect (CPE), and the Crossed Cylinder Effect (CCE).

A front toric GP lens has a spherical base curve and a toric front surface. This lens is indicated for patients in whom the total refractive astigmatism contains significant internal physiologic astigmatism, and in whom the anterior corneal toricity is less than 2.50 Diopters. This lens design is not indicated in this case.

A back, or base, toric lens is the opposite of the front toric lens. This lens is indicated for patients in whom there is an anterior corneal toricity of greater than 2.50 Diopters, and a total refractive astigmatism that is equal to roughly one-quarter to one-half the difference in the base curve toricity and is of the same axis. The use of this lens design is very limited, and does not apply to this case.

However, understanding the impact of the base curve on the eye is essential to understanding not only the back toric lens but also the birtoric lenses. Further, this concept is one of the most misunderstood concepts in contact lens practice.

Placing a toric posterior lens surface against the eye induces a cylindrical error. The cornea / tear interface has almost no power due to the similar indices of refraction of the cornea and the tear film, while the tear / lens interface has significant power due to the significant difference in the indices between the tear film and the lens material. The higher the lens material index is, the greater the induced cylinder. The amount of this induced cylinder determines when a back toric lens is indicated, and it affects the bitoric designs.

When it was first discovered that the base curve induced a cylinder, the only lens material available was P.M.M.A., which has an index of refraction of 1.49. Today, there are GP materials that have significantly lower indexes that induce significantly lower astigmatic errors. With a lens material like Boston™ EO which has a low index of refraction (1.43), the induced cylinder drops to almost exactly one-quarter.

In this case, an SPE bitoric lens is indicated for both eyes. An SPE bitoric lens is indicated for patients in whom the anterior corneal toricity is greater than 2.50 Diopters and is, essentially, equal to the total refractive astigmatism. In that

instance, a lens that behaves optically as though it were a spherical lens would neutralize the ammetropia completely, but a toric base curve is indicated.

An SPE bitoric lens has a cylinder that is equal, but opposite in orientation, to the induced cylinder created by the toric base curve. First postulated by Sarver in the early 1960's, this lens has a toric base curve to align a highly toric corneal surface, but provides spherical optics. This option is ideal for J.N.

One can infer that the amount of compensating cylinder for the SPE bitoric changes with the index. Because the amount of correcting cylinder is decreased, bitoric lenses are best made from a material with a low index of refraction. These lenses are thinner, and they have less mass. These lenses are easier to control, and are generally more comfortable.

With that in mind, a low index material was desired. This author also believes that a stiff material will hold the desired shape in a thinner design, and will machine to a higher quality. The material chosen was Boston™ EO for its low index and superior stiffness. The only drawback is that the material has a high specific gravity, which makes the lens heavier.

The following lenses were ordered, and the patient was dismissed. He was told that he would be notified upon their delivery:

New GP Lens Parameters:

Lens Parameter	OD	OS
Overall Lens Diameter:	9.60 mm	9.60 mm
Posterior Optic Zone Diameter:	8.00 mm	8.00 mm
Base Curve Radii:	7.80 mm / 7.50 mm	7.80 mm / 7.25 mm
Back Vertex Drum Powers:	- 4.00 D / - 5.37 D (SPE)	- 2.75 D / - 6.00 D (SPE)
Anterior Optic Zone Diameter:	8.40 mm	8.40 mm
Center Thickness:	T.A.P.	T.A.P.
Edge Thickness:	0.13 mm	0.13 mm
Secondary Curve Radius:	BC + 0.80 mm	BC + 0.80 mm
Tertiary Curve Radius:	BC + 1.00 mm	BC + 1.00 mm
Tertiary Curve Width:	0.30 mm	0.30 mm
Quaternary Curve Radius:	BC + 1.50 mm	BC + 1.50 mm
Quaternary Curve Width:	0.20 mm	0.20 mm
Prism:	None	None
Blend:	Moderate	Moderate
Lens Material:	Boston EO™	Boston EO™
Lens Color:	Blue	Blue

The right lens was dotted for identification. It is important to specify "SPE" when ordering an SPE lens so that the lab can compensate for the lens index. By designing the peripheral curve set by progressively increasing the base curve radii, one creates toric peripheral curves. This design has the advantage of maintaining toric alignment and also maintaining a round optic zone.

One last note, the spectacle prescription was withheld because it might change after the new lenses were worn. A final spectacle prescription would be offered at a follow up visit.

Dispensing Visit: October 12, 1999

The lenses were received on October 8, 1999, the parameters were verified, the lenses were cleaned and stored in fresh Boston™ Original Soaking Solution, and the patient was scheduled.

On October 12, 1999, J.N. presented and inserted the lenses at 12:24 pm and they were allowed to equilibrate until 12:47 pm. The patient reported improved comfort in both eyes, as well as great visual acuity. The following data were collected:

Distance Acuity with New GP Lenses:

OU	**20 / 15**	**Stable**
OD	**20 / 20**	**Stable**
OS	**20 / 20**	**Stable**

An over-refraction was not done at the dispensing visit because of the exceptional acuity and because it was likely to change slightly as the patient wore the lenses. Both lenses centered laterally and decentered superiorly in a lid attached fashion without lag. Each lens moved 1.50 mm in primary gaze. The fluorescein pattern appeared to simulate around one Diopter of toricity, with alignment roughly along the horizontal.

The lenses were dispensed to the patient with a Boston™ Original sample care kit. Since J.N. had been wearing his old spherical lenses full time, the lenses were dispensed without a change in wearing time. Further, since he was already using the Boston™ Original care system, little instruction was needed in that

regard. However, the patient was instructed to replace his case every two months to decrease the risk of microbial cross-contamination. He was instructed to return in two weeks for a contact lens follow-up visit.

First Contact Lens Follow-Up Visit: October 21, 1999

The patient presented at 12:13 pm having worn his new lenses for four and a half hours. His habitual wearing time was still twelve hours. He reported great comfort and vision in both eyes. He denied any problems with insertion or removal. It is important for one to ask about insertion and removal when one changes the lens geometry. A lens that aligns too tightly can be difficult to remove. The following data were collected:

Distance Acuity with New GP Lenses:

OU	**20 / 15**	**Stable**
OD	**20 / 20 + 1**	**Stable**
OS	**20 / 20 + 1**	**Stable**

Sphero-Cylinder Over-Refraction:

OD	**- 0.25**	**Sphere**			**20 / 20 + 1**	**Stable**
OS	**- 0.25**	**- 0.25**	**X**	**152**	**20 / 20 + 1**	**Stable**

The lenses both still positioned superiorly, but now they lagged inferiorly about 1.00 mm roughly twenty-five percent of the time. The lenses were decentered temporally about 1.00 mm. The fluorescein patterns were essentially unchanged from the dispensing visit.

The inferior arcuate staining pattern was better, but not gone. The lenses were then removed and the eyes were evaluated again. The corneas were free of defect, except for a small area of Grade I + superficial micro-punctate keratitis centrally in the left eye. The nature of this injury was probably mechanical. However, the lens alignment was ideal. Perhaps, this injury occurred upon insertion. The patient was unaware of any comfort issues.

The following data were collected:

Manifest Refraction:

OD	**- 4.50**	**- 2.50**	**X**	**010**	**20 / 20**
OS	**- 3.25**	**- 5.50**	**X**	**164**	**20 / 20**

A spectacle prescription was written, and the patient was instructed to be careful with insertion. Because of the central staining on the left cornea, J.N. was instructed to go one day without his lenses, resume his lens wear on the following day, and to return in one week for a quick check of the corneal staining.

Second Contact Lens Follow-Up Visit: October 27, 1999

J.N. presented at 10:45 am, having worn his lenses for three hours. He claimed complete compliance with the treatment plan of discontinuing his lens wear for one day, and he was back to around twelve hours per day. He denied any problem with his eyes, his vision, or his contact lens wear. He reported that he had purchased new spectacles from the prescription issued the week before.

The patient's acuity through his lenses was unchanged. The patient removed his lenses, and he was evaluated at the slit lamp. The central staining pattern was resolved. The inferior arcuate staining pattern was minimal, but not gone. The persistence of this injury was probably due to the intermittent lens lag that was still present. However, the extent of the stain had decreased with time, and it was decided that no further intervention was indicated. J.N. was instructed to continue his wearing schedule and lens care regimen, and to return in six months for another follow-up visit.

Third Contact Lens Follow-Up Visit: April 13, 2000

The patient presented at 2:00 pm, having worn his lenses for approximately five hours. He reported no problems with comfort or acuity. His acuity and his over-refraction were, essentially unchanged. The small arcuate staining pattern observed in the inferior limbal sulcus was now present only in the left eye, and it was minimal. No further intervention was indicated. The patient was released to annual care, and was set for recall in six months.

CONCLUSION

This case demonstrated perfectly the use of SPE bitoric lenses. The second type of bitoric GP lens, a CPE bitoric lens, is indicated for patients in whom the anterior corneal toricity is greater than 2.50 Diopters, but is significantly different from the total refractive astigmatism.

The third type, the Crossed Cylinder Effect (CCE) lens is a little used but valuable tool. This lens is indicated when the principal corneal meridians are misaligned with the total refractive astigmatic axis by more than twenty degrees. The SPE and the CPE bitoric lenses have the principal meridians on the front and the back of the lens aligned. On the CCE lens, the principle meridians on the front of the lens are not aligned with the meridians on the back of the lens to account for the misalignment between the corneal and the refractive cylinder. Roughly fifteen percent of the bitoric lenses prescribed fail due to poor acuity, and, most of the time, a CCE lens will solve the problem. CCE lenses were quite difficult to make on the older single axis lathes, and reproducing them was next to impossible.

However, the latest generation of multi-axis lathes allows the prescriber to contemplate and utilize complex lens designs, and just as important, reproduce them with great fidelity.

With the new lathes, one can also place complex edge geometries on lenses to improve lens positioning and comfort. The curves are no longer applied by hand. This author thinks that spherical peripheral curves should only be used on toric lenses when the corneal topography indicates that the corneal toricity is limited to a small central area. Therefore, toric peripheral curves were used.

Another question that remains is what to do about the lens design when the principal meridians are not on the horizontal and the vertical. Oblique

astigmatism requires a slightly different approach. For those patients, the low toric simulation design is not appropriate. Rather, good alignment in all directions yields the best lens dynamics. This design is called the "saddle" design. Saddled lenses have a higher amount of toricity on the back surface which in turn induces a greater cylinder for which to compensate. Therefore, the junctional thicknesses of saddled lenses are thicker when compared to low toric simulation lenses.

The final point of this report centers on the inferior arcuate staining and the central corneal staining of the left eye noticed at the first follow-up visit. It is vitally important to distinguish what "normal" is. Being able to do so helps the practitioner recognize instantly even subtle abnormal findings. However, it is equally important to recognize when intervention is required and when it is not. Many times, practitioners get into trouble by fixing things that aren't broken. Sometimes, like in the case of the central corneal injury observed at the first follow-up, an abnormal find is coincident and self-limiting. Observation was the best course of action in this case. An automatic assumption that something was wrong with the prescribed lenses would lead the prescriber into making the error of changing the lenses when the best design had already been achieved. Prudence and taking in the entire constellation of signs and symptoms is crucial when making these types of discriminations.

While market penetration of GP lenses has declined due to newer technologies, the use of toric GP lenses, especially bitoric lenses, continues to be a niche for providing stable, unrivaled vision with good comfort.

A thorough knowledge of all of the toric GP lens designs gives the prescriber a powerful armamentarium with which to attack problems that few optometrists, ophthalmologists, or contact lens technicians are equipped to handle. Expertise in the prescribing of GP lenses in general, and toric lenses in particular, is fast becoming a lost art. However, the prescribing of toric GP lenses can be challenging, but highly rewarding, both professionally and financially.