A Comparison of Aspheric Contact Lenses, Spherical Contact Lenses, and the Eccentricity Value of the Cornea

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Abstract

Autokeratometry readings were taken on a total of six patients (12 eyes). The patients were then fitted with aspheric lenses with an eccectricity value of 0.6, recording the fluoriscein pattern, lens movement and centration. Next, a spherical lens with parameters comparable to the parameters of the lens which fit "on K" was placed on the eye, and the fit and centration were analyzed. A comparison between the fits and the eccentricity value measured by the autokeratometer was also made.

Introduction

The Humphreys autokeratometer is capable of measuring the eccentricity value of the aspheric cornea. The eccentricity value, or e-value, is a measure of the degree of flattening, or decrease in curvature, of a curve. A higher e-value indicates a more rapid decrease in curvature. The possibility exists that this value could prove useful in determining the proper parameters to use in fitting a rigid gas permeable (RGP) contact lens. One goal of this experiment was to determine if this value indeed provided usable information to the contact lens fitter. The other goal of this experiment was to evaluate any correlation between the autokeratometer's e-value with an e-value estimate based on the fit of the aspheric trial contact lenses.

Background

The cornea is aspheric, flattening out as one moves from the center to the periphery. Most rigid contact lenses, however, are spherical. As a result of this it is necessary to modify the basic spherical lens design in order to have a lens which more closely matches the shape of the eye. An unmodified lens would fit as in figure 1. The most common

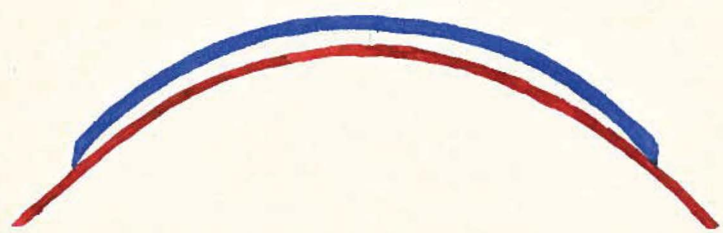
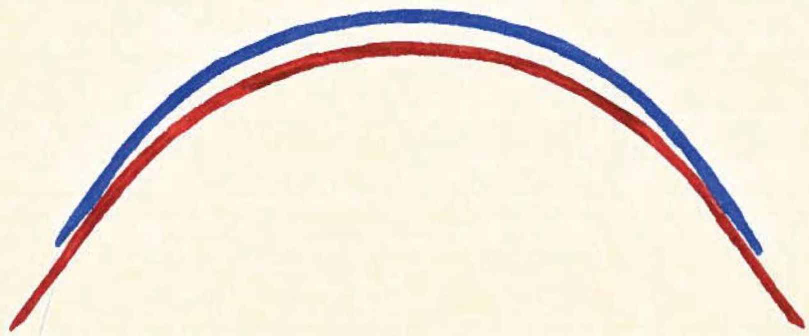


Figure 1: Spherical lens on aspheric cornea. Note the central clearance and peripheral contact.



<u>Figure 2</u>: Spherical contact lens with peripheral curve. Note the point of touch at the junction of the primary and secondary curve.

modification is the addition of a peripheral curve. This allows the basic shape of the lens to more closely match the shape of the cornea (figure 2). However, there is still a point where the cornea and lens touch at the junction of the primary and secondary curve. At this point an option is to add another peripheral curve (figure 3). This would create an additional point of touch.

It should be fairly obvious to realize that each additional peripheral curve added to the lens will allow the shape of the lens to more closely match that of the cornea. With that in mind, let us imagine a lens with an infinite number of peripheral curves, each one just slightly flatter than the last one. That lens would gradually flatten out toward the edges, and the points of touch that are present on

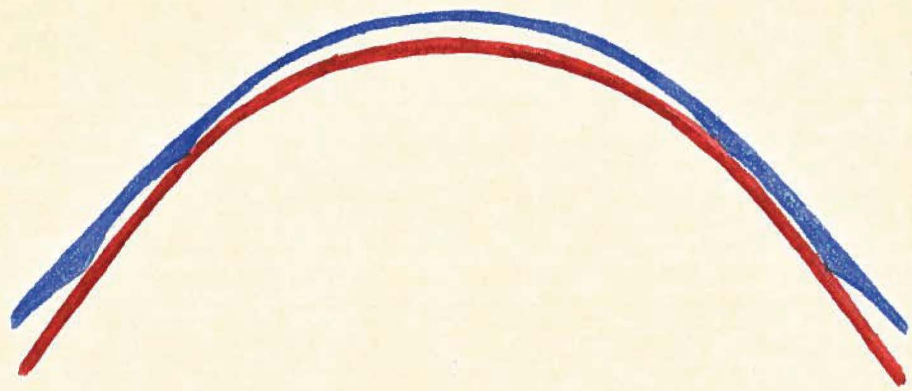


Figure 3: Spherical Contact lens with two peripheral curves.

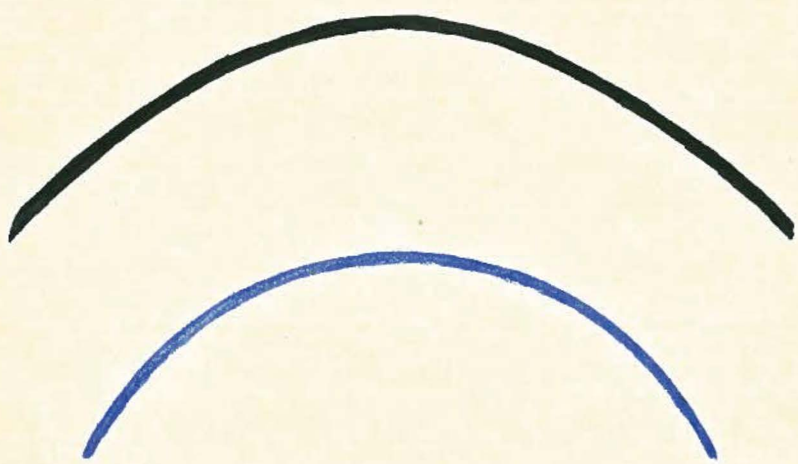


Figure 4: Aspheric (black) and spherical (blue) contact lenses.

the previous lenses would smooth out into a flat surface. What you would then have would be an aspheric lens (figure 4).

Even so, asphericity itself does not guarantee a proper fit. Imagine two aspheric lenses, one of them flattening twice as fast as the other. In other words, the two lenses have different e-values. The lenses would appear as they do in figure 5. Both of those lenses would not fit on the same cornea. Therefore, it is important to know the e-value of both the cornea and the lens being fit, because both the base curve and the e-value affect the lens fit. This also illustrates the importance of knowing the parameters of the peripheral curves of a spherical lens: Two lenses with equal base curves and different peripheral curves are not going to fit the same.

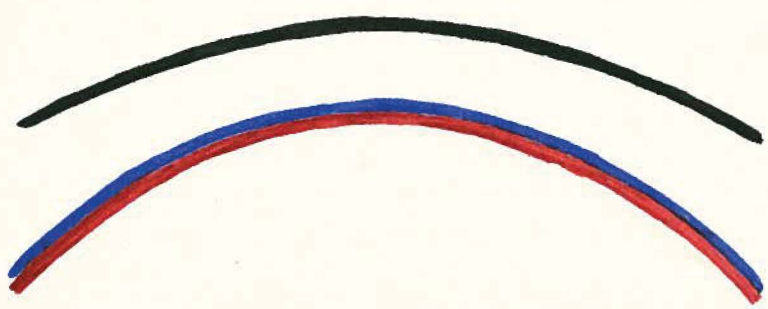


Figure 5: Two aspheric lenses with different e-values. Note that the first lens would not fit on the cornea shown, although it has the same base curve as the cornea and the other lens.

Method

Autokeratometry readings were taken on six subjects (12 eyes). A lens from the ELS trial lens fitting set was then selected for placement on the patient's eye. The initial lens selected was the lens whose base curve most closely matched the central autokeratometry reading in the flatter meridian. The patient's eye was then anaesthetized with one drop of tropicamide 1%, and the lens placed on the eye.

After approximately two minutes wait for the lens to settle, fluorescein was instilled in the eye, and the fluorescein pattern, lens movement, and centration were recorded. Fluorescein patterns were graded as being steep or flat, in increments estimated to the nearest 0.25 diopters. This system was borrowed from Lowther.1 If the lens was fitting flat, a steeper lens was placed on the eye, and the procedure repeated, and vice versa for a steep fitting lens.

Once it was determined which lens fit "on K" or nearest to it, a spherical lens of equal base curve to the "on K" lens was then placed on the eye and evaluated in the same manner as the ELS lenses.

Results

Central keratometry readings in the flatter meridian ranged from 41.25 to 46.37, with an average reading of 43.87. E-values ranged from .01 to .57. Initial ELS lens fitting ranged from "on K" to 1.00 diopter flat. The difference between the flatter K-reading and the base curve of the "on K" aspheric lens (K-reading - base curve) ranged from -.14 to +.11.

All but two of the lenses fit were steeper than the K-readings taken. In these cases the difference between the base curve of the ELS lens which fit on K and the K reading in the flatter meridian was +.11. These eyes had an e-value of .57, the steepest e-value measured. One eye had no difference between the base curve and the K-reading, and this eye had an e-value of .42. The largest difference between the base curve of the on K ELS lens and K readings was -.14.

E-values	Flatter K reading	BC of On K ELS Lens	Difference Between BC and K	Spherical Lens Fit
.17	7.63	7.58	-.05	+1.00
.20	7.64	7.50	-.14	+1.50
.01	7.36	7.22	-.14	+1.00
.30	7.23	-	-	on K
.57	7.87	7.98	+.11	+2.00+
.57	7.90	8.01	+.11	+2.00+
.42	7.24	7.24	0.00	+0.75
.52	7.22	7.20	-.02	+1.75
.48	7.62	7.54	-.08	+2.00
.54	7.48	7.40	-.08	+2.00+
.37	7.80	7.74	-.06	+0.75
.34	7.77	7.74	-.03	+0.75

Table I

The eyes which had this value had e-values of 0.01 and 0.20. The pattern which arises is that the lower the e-value, the more steeply the lens must be fit. However there are exceptions to this rule. Eyes with e-values of .54 and .48 had lenses fit .08 mm steep. One eye was too steep to fit a diagnostic lens on K. However, the spherical lens which most closely matched the steepest ELS lens (both had base curves of 7.2) fit on K, while all other spherical lenses fit steep.

Conclusions

The corrrelation between the fit of the aspheric lens and the e-value of the cornea did not follow the expected pattern, although the general principle was followed. Since the e-value of the lenses was .6, one would expect these lenses to fit on K when placed on eyes with e-values close to .6. In fact, when the e-value neared .6 (.57, 2 cases) the lenses actually needed to be .11 mm flatter. The lens fit on K when the e-value was .42 (1 case). Three eyes had e-values between these values, with e-values of .48, .52, and .54. In these cases the diagnostic lenses fit .08, .02, and .08 mm flat, respectively.

All eyes with e-values of .48 or higher fared equally in the spherical lens comparison. In these cases (5 in all) the spherical lens fit was at least 1.75 diopters steep, which correlates with the theory that as the e-value increases a spherical lens would not fit the same as an aspheric lens; instead it would fit steep (see figure 6, page 10).

Additionally, all eyes with e-values below .48 had spherical lens fits ranging from +0.75 to 1.50 diopters steep. This evidence supports the validity of the e-value readings of the Humphreys autokeratometer.

The average e-value is .38 +- .19, and the average difference between the base curve and the (flatter) keratometry reading is -.034 +- .084. Such high standard deviations indicate that the data is highly variable. One would expect a certain amount of variation among these values. This is of less concern than the fact that the differences do not correlate with the e-values themselves.

However, linear regression shows the slope of the line e-value vs (BC-K) to be 1.53 with a correlation coefficient of .69. This correlation coefficient indicates a 95 to 99% certainty that the data fits the linear regression line. In other words, we can be 95 to 99% sure that there is a linear relationship between the e-value and the difference between the base curve and keratometry readings. This again supports the validity of the e-value readings.

Even so, does the e-value provide useful information to the contact lens fitter? The answer is yes and no. To the practitioner who bases his prescription primarily on fluoriscein patterns, the additional information would not be of much concern. However, if a practitioner encounters a patient whose fitting does not follow expected patterns, then the e-value might be able to explain what is happening. For example: A patient is fit with a lens which, according to K readings, should fit on K. Actually, it fits steep, and the patient needs a considerably flatter lens to achieve an on K fit. E-value readings would reveal that this patient has a considerably high e-value, which would result in the initial lens fitting flat.

Therefore, even though the e-value is not an essential tool to the hard contact lens fitter, it very well could explain some seemingly contradictory situations in a contientious practitioner's office.

References

1. Lowther, Gerald E. and Hammack, Glenn. Contact Lens Videodisc Series.

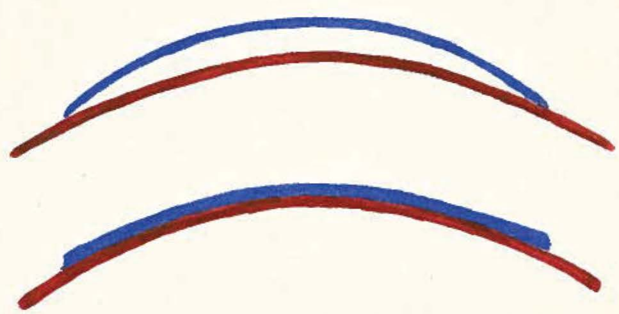


Figure 6: Spherical lens and aspheric lens on the cornea. Note the central clearance with the spherical lens, even though both lenses are the same base curve.