MECHANISM
OF
TORIC HYDROGEL LENS
FIT

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Optometry 797
Special Studies
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April 19, 1994

ABSTRACT

Toric hydrogel contact lenses present a multiplicity of challenges in the fitting process. Factors such as lens thickness, lens adherance, lens hydration, lid shape & movement, and center of gravity affect the lens fit. In spite of these variables, this study proposed that the mechanism by which toric hydrogel contact lenses correct corneal astigmatism involves sphericalization of the eye-lens system. The Eyesys Corneal Analysis System was utilized to establish the cylinder power and axis as well as for calculation of keratometric data. The study found that both an established toric hydrogel lens wearer and an emmetropic patient with a nearly spherical cornea who had a toric lens placed on the eye supported the concept of sphericalization. Non-established toric hydrogel lens wearers did not support the hypothesis. The potential impact of a possible tear lens effect and a potential adaptation period was addressed.

INTRODUCTION

Astigmatism is a common refractive error for which correction is needed. Estimates are that approximately 35 percent (1) of the 146 million Americans requiring vision correction have a diopter or more of refractive astigmatism. (2) In the past, patients with moderate amounts of refractive astigmatism have had limited success with spherical hydrogel contact lenses to correct their refractive error. These patients typically experienced a residual refractive error corresponding closely to the uncorrected astigmatic component of their refractive error. (3) The limit of acceptable uncorrected refractive error tolerated by the patient varies; however, a general rule of thumb is that patients tolerate a limit of 0.75 to 1.00 D residual refractive error with hydrogel lenses. (4)

The advent of toric hydrogel contact lenses has enabled many patients with previously "tolerable" vision with spherical hydrogels to realize a true increase in visual clarity thereby decreasing residual refractive error to negligible amounts. The purpose of this study was to evaluate the mechanism by which toric hydrogel lenses correct astigmatic refractive errors. The hypothesis was made that a properly fit toric hydrogel lens on a toric cornea would essentially create a sphericalized anterior lens surface.

MATERIALS & METHODS

The initial experimental design was to evaluate four to six eyes having 1.00 to 2.00 D of corneal astigmatism both before and after placement of a toric hydrogel lens on the eye. Patients were between 20 and 35 years of age and were not established toric hydrogel lens wearers. The Eyesys Corneal Analysis System was utilized to acquire the cylinder axis and power of the patient's astigmatic component. A toric hydrogel lens was chosen which corresponded as closely as possible to their cylinder axis and power. The lens was placed on the eye and when tearing subsided (generally in 10 to 15 minutes), rotation of the lens was noted with a slit lamp evaluation. If the lens was rotating more than 5 degrees, the LARS principle was used to arrive at another lens closer in axis to actual corneal toricity. When the lens mechanically matched the cornea, another Eyesys Corneal Analysis was completed over the lens in vivo to determine how much toricity existed and at what axis it occurred.

Two other circumstances were considered and tested for comparison purposes. An established, successful toric hydrogel lens wearer was evaluated with the Eyesys Corneal Analysis System. After having worn the lenses for approximately six hours, an Eyesys Corneal Analysis was completed. Then the lenses were removed, and Eyesys was performed again on that eye. A second case involved an emmetropic patient with a nearly spherical cornea. An Eyesys Corneal Analysis was done on the eye before placing a toric hydrogel lens on the eye. A lens was then placed on the eye and another corneal analysis performed. An over-refraction was then done to confirm the refractive error created by placing the lens on the eye.

RESULTS

Patient #1 had an OS pre-lens keratometric data of 46.87 @ 73 and 45.24 @ 163 with Δ K 1.63 @ 73. (See Figure 1) This patient was fitted with a Hydrocurve II toric hydrogel lens with BC 8.9 and diameter 14.5. The lens power was -3.00 -1.25 x 160. This lens is a back surface prism ballasted toric hydrogel. The lens exhibited minimal rotation. The keratometric data with the lens in place was

44.58 @ 93 and 42.88 @ 03 with △ K of 1.70 @ 93. (See Figure 2) Subsequent non-established hydrogel lens wearers evaluated produced similar results.

Patient #2 was an established, successful toric hydrogel lens wearer. This patient came in with both lenses on after approximately six hours of wear. The lenses were Hydrocurve II toric hydrogels with BC's of 8.8 and diameters of 14.5. The lens powers were as follows: OD -4.00 -1.25 x 150 and OS -4.25 -1.25 x 020. The keratometric data with the OD lens in place was 41.82 @ 21 and 41.66 @ 111 with △K of 0.16 @ 21. (See Figure 3) The post-lens keratometric data OD was 45.48 @ 75 and 43.88 @ 165 with △ K 1.60 @ 75. (See Figure 4) Keratometric data with the OS lens in place was 41.56 @ 80 and 40.95 @ 170 with △ K 0.61 @ 80. (See Figure 5) The post-lens keratometric data OS was 47.13 @ 85 and 45.60 @ 175 with △ K 1.53 @ 85. (See Figure 6)

Patient #3 was an emmetropic patient with a nearly spherical cornea OD. From the Eyesys Corneal Analysis the pre-lens keratometric data was 43.04 @ 73 and 42.77 @ 163 with △ K 0.27 @ 73. (See Figure 7) A Torisoft hydrogel with BC 8.9 and diameter 14.5 and -3.00 -2.50 x 180 power was placed on the eye. Rotation was noted, and Eyesys Corneal Analysis was again completed. Keratometric data with the lens in place was 40.66 @ 37 and 39.24 @ 127 with △ K 1.42 @ 37. A subsequent over-refraction revealed residual refractive error of +5.50 -2.25 x 120.

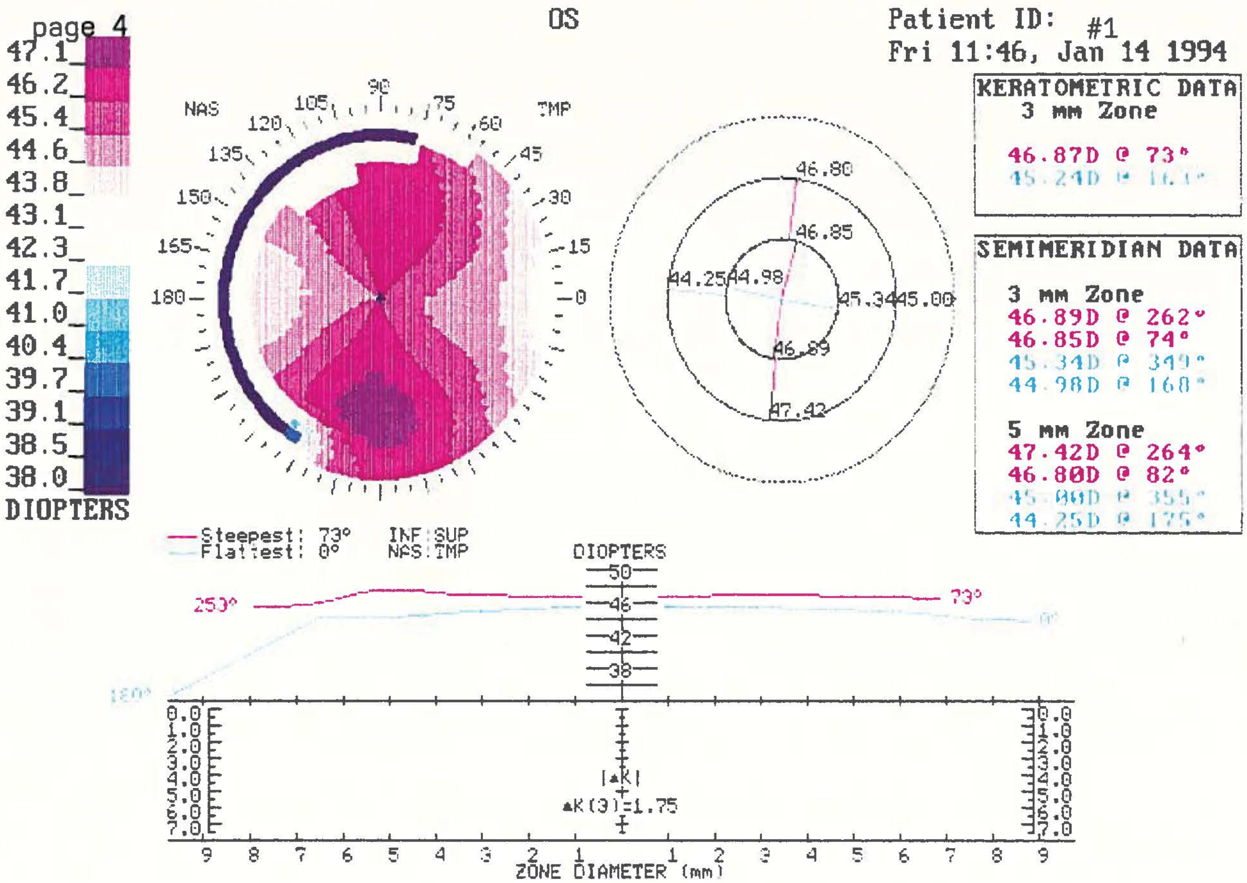

Figure 1

EyeSys Corneal Analysis System

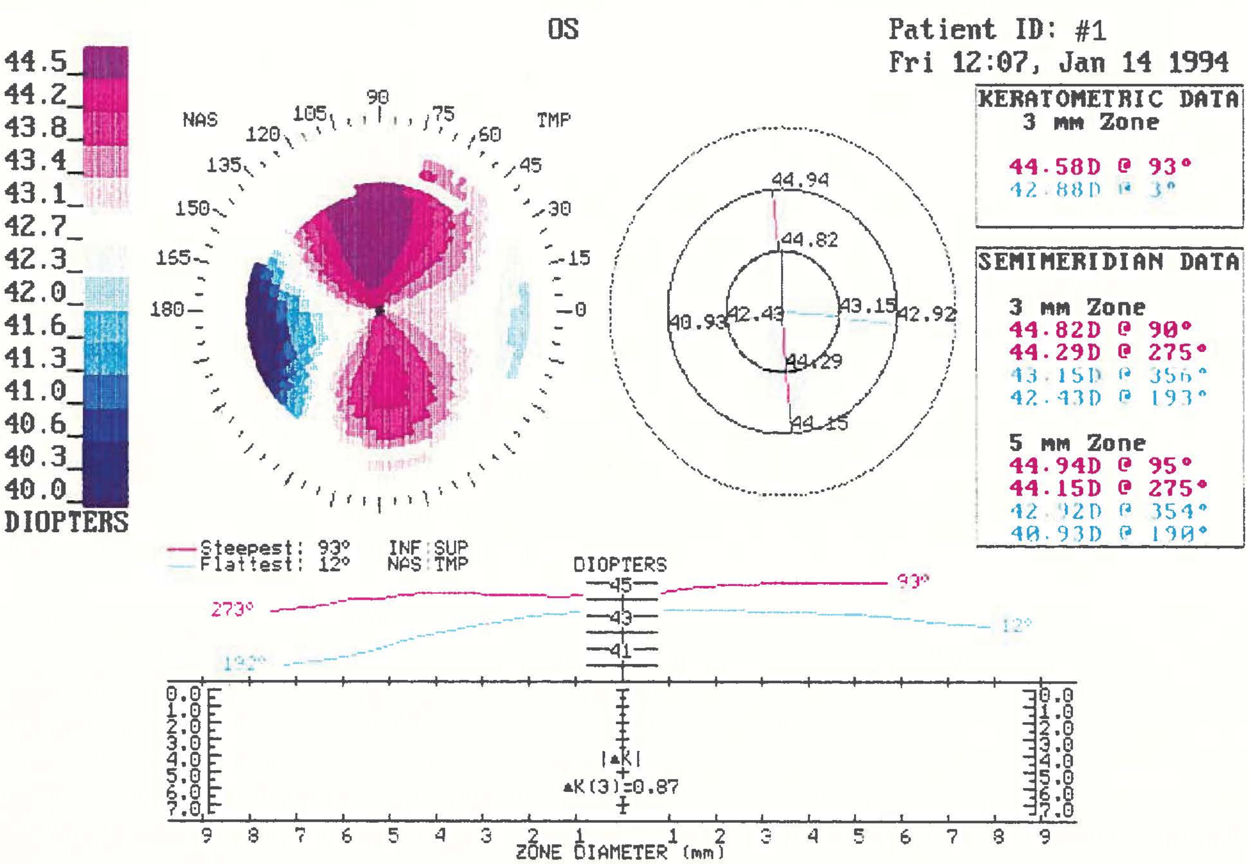

Figure 2

EyeSys Corneal Analysis System

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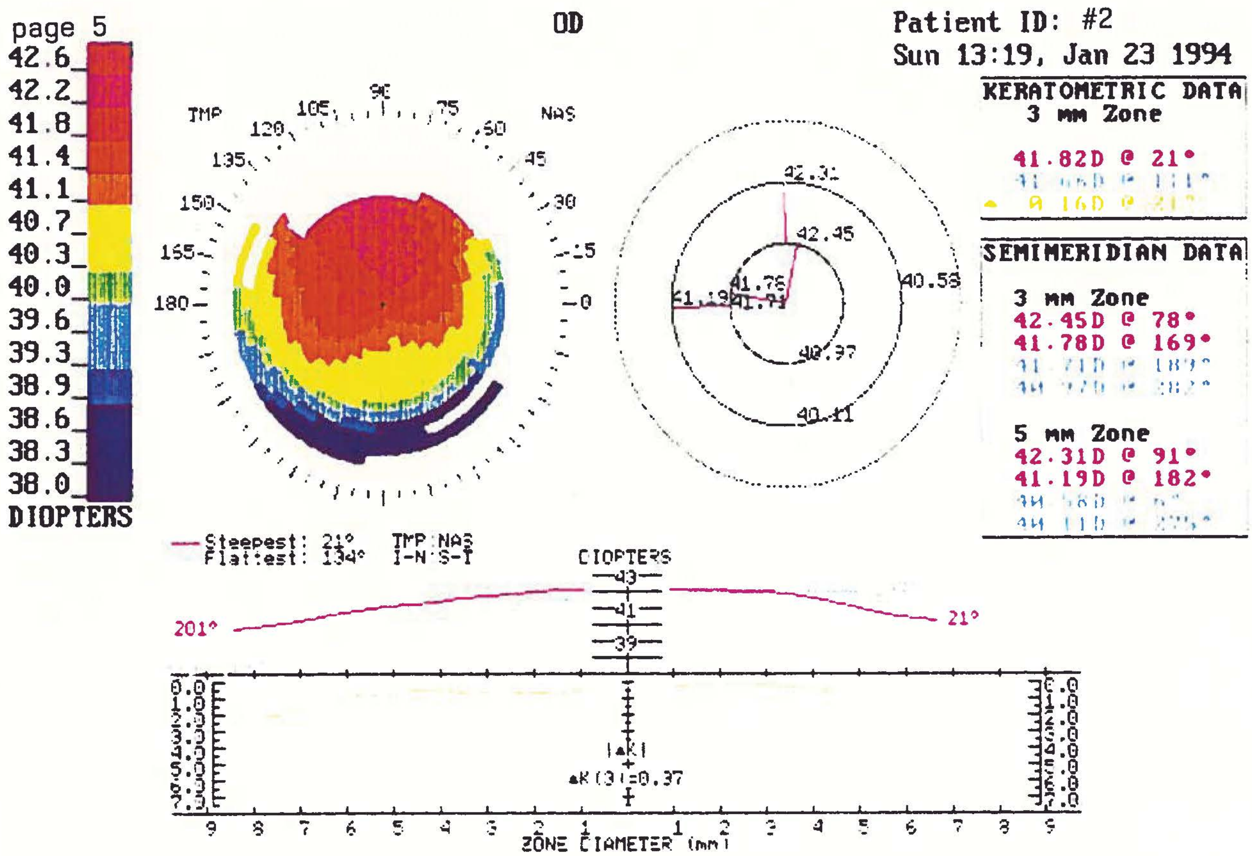

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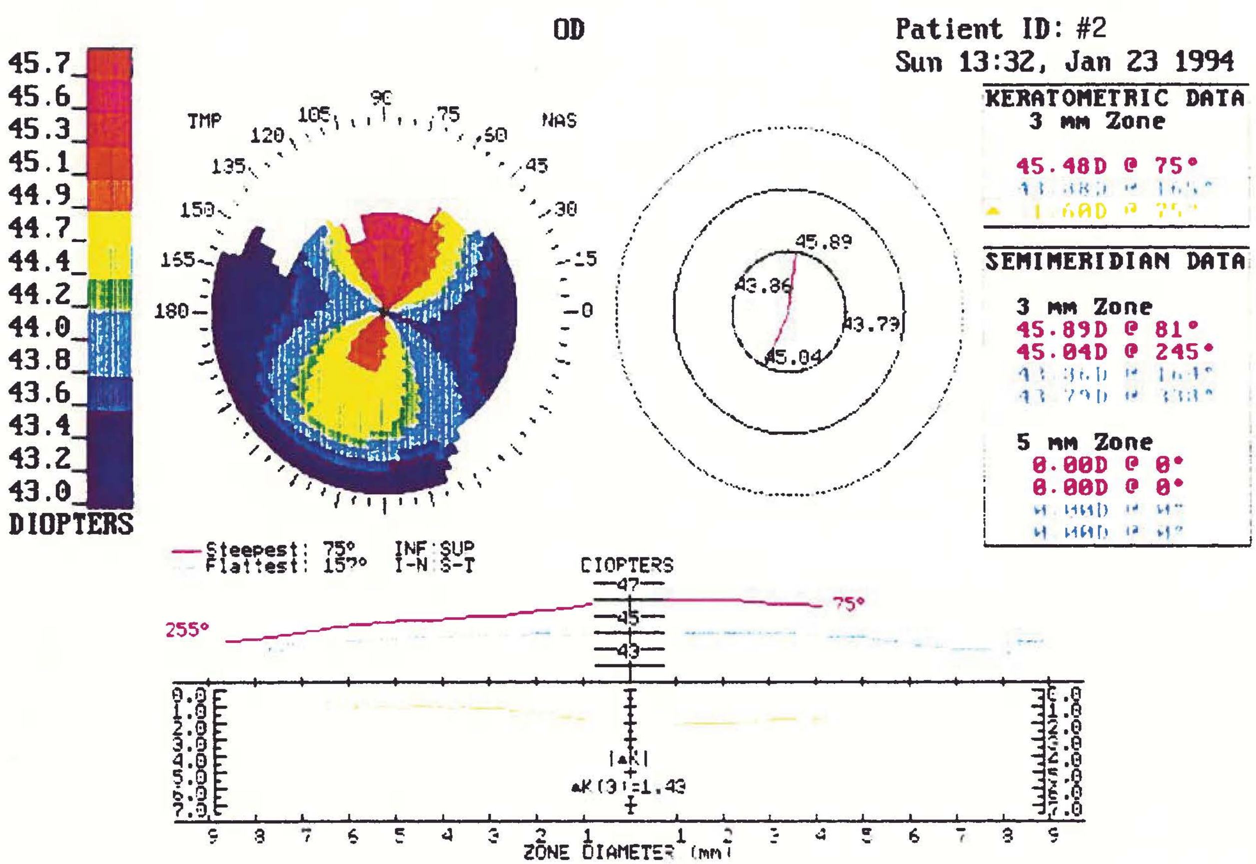

Figure 4

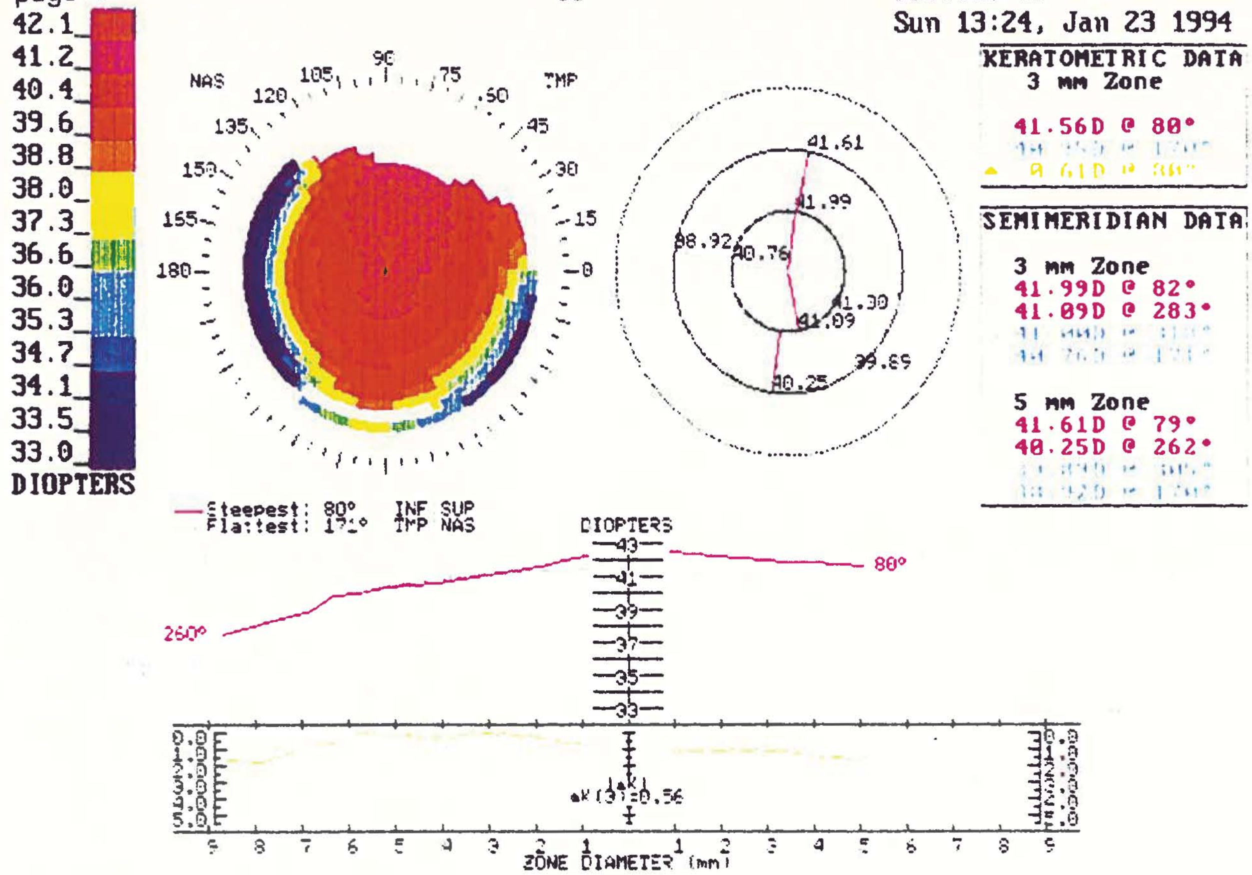

Figure 5

EyeSys Corneal Analysis System

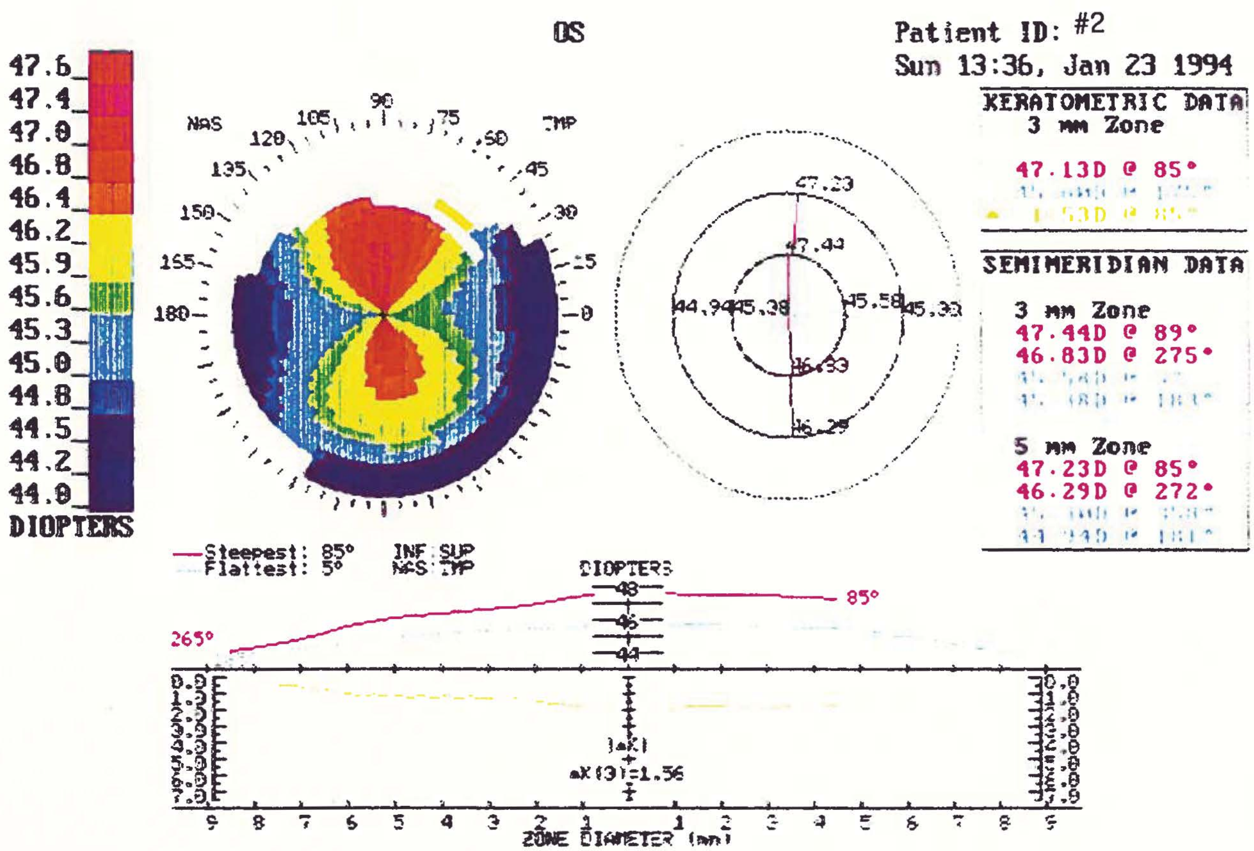

Figure 6

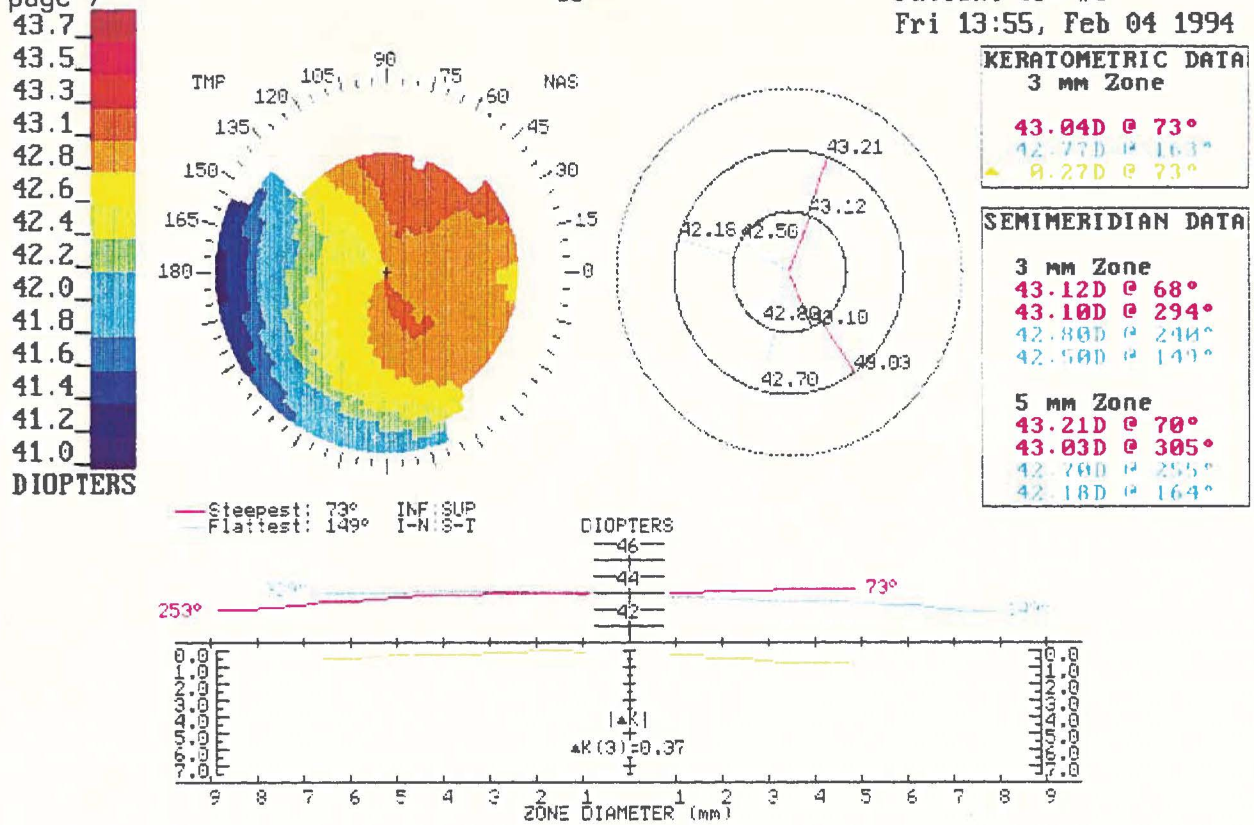

Figure 7

EyeSys Corneal Analysis System

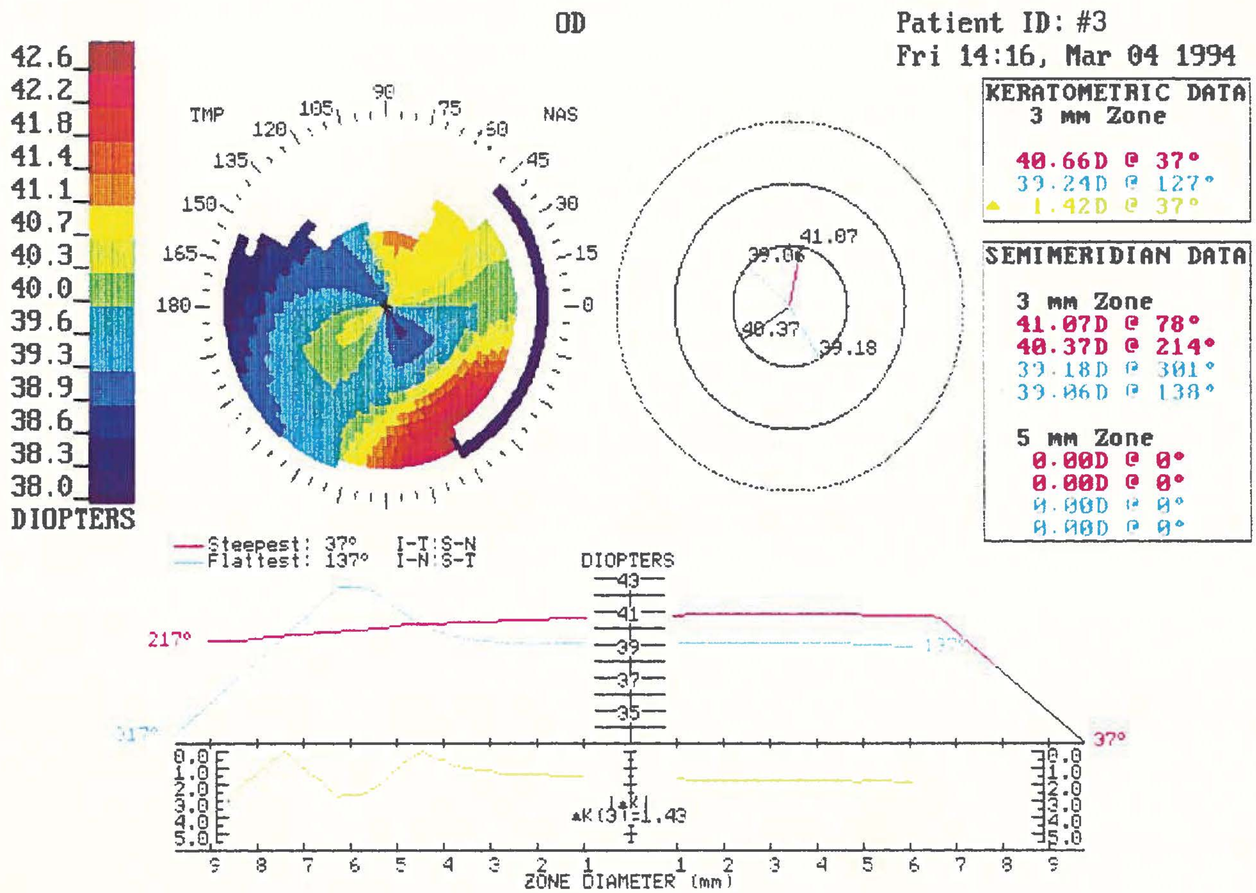

Figure 8

EyeSys Corneal Analysis System

DISCUSSION

In order to reduce residual astigmatic refractive error on a toric cornea, a toric lens is necessary when using hydrogels. On a WTR cornea (x 180) the steepest meridian of the cornea is vertical, and the flattest meridian is horizontal. A toric hydrogel lens that fits appropriately on a WTR cornea needs to have the thickest part of the lens riding over the steepest meridian (i.e., the vertical meridian). On an ATR cornea (x 90) the steepest meridian of the cornea is horizontal, and the flattest meridian is vertical. Here the thickest part of the toric hydrogel needs to ride over the horizontal meridian. Therefore, the stability of a toric hydrogel on the cornea significantly influences the ability of the lens to satisfactorily correct the astigmatic refractive error.

Since hydrogel contact lenses lack "shape constancy" (5), several factors contribute significantly to the positioning of the lens on the eye. Some of these factors include lens thickness, lens adherance, lens hydration (involving tonicity, pH, humidity & temperature), lid shape & movement, and center of gravity of the lens. (6) Because the fitting of a toric hydrogel is highly dependent on such a wide range of factors which change emphasis from individual to individual, isolating one component of the fit for assessment is extremely challenging. The purpose of this study was not to try to attempt to rule out all the other variables involved in fitting, but to see that in spite of all the variables, the toric hydrogel still essentially resulted in a more spherical surface on the eye.

Patient #1 did not exhibit the expected sphericalization with the toric hydrogel on the eye. The patient, in fact, exhibited an increase in toricity with the lens in place. In comparison, the established lens wearer, patient #2, did exhibit the expected sphericalization. In both eyes the astigmatic component of the refractive error was minimized. Keratometric data indicated that a Δ K of 0.16 D OD and 0.61 D OS remained with placement of the toric hydrogel lenses on the eyes. In addition, the emmetropic patient with the nearly spherical cornea, patient #3, was expected to have a refractive error in both the spherical and cylindrical components equal to but opposite that of the toric lens placed on the eye. Since the lens placed on the eye was -3.00 -2.50 x 180, the expected refractive error was +3.00 +2.50 x 180 , which is +5.50 -2.50 x 90 in minus cylinder form. The toric lens rotated on the eye 45 degrees to the right. Using the LSRA principle, the lens would be expected to rest at an axis of 45. The Δ K from the Eyesys Corneal Analysis was 1.42 D which underestimated the refractive error created by the lens. This is an expected finding with this particular analysis system which tends to underestimate cylinder by as much as one-third. The retinoscopy/sphere-cylinder over-refraction revealed a refractive error of +5.50 -2.25 x 120. This would imply that the thickest, most minus meridian was at axis 120 with the thinnest, least minius meridian at axis 30. When a lens equivalent to a -3.00 -2.50 x 45 is placed on a nearly spherical cornea, the 135 meridian which has power of -5.50 would be expected to be the flatter meridian because it is the thickest, most minus meridian. The 45 degree meridian would be expected to have the steepest meridian because it is the thinnest, least minus meridian. The Eyesys Corneal Analysis indicated that the axis of the lens was at 127; therefore, the thickest and flattest part of the lens was at axis 127. The thinnest and steepest part of the lens was at axis 37 according to the Eyesys

Corneal Analysis. The axis of the thickest meridian from the eye-lens system corresponds within 8 degrees of the Eyesys computation of the thickest meridian. Therefore, patient #3 met the fitting expectations when placing a toric hydrogel lens on a nearly spherical cornea.

The lack of sphericalization exhibited by placing mechanically matched toric hydrogel lenses on toric corneas of nonestablished toric hydrogel lens wearers raised an additional dimenaion to the study. While trying to determine potential reasons for lack of sphericalization in this group, it was further hypothesized that the eye-lens may actually be under the influence of a tear lens effect. Generally, a tear lens effect is not considered to be a significant aspect of fitting hydrogel lenses due to the flexibility and draping effect of the lenses. However, the existence of a tear lens could actually be a problem encountered upon initial insertion of the lenses on a routine basis, even in established toric hydrogel lens wearers. The lenses may require a period of adaptation with every insertion during which the visual capabitity of the patient is compromised. This raises questions about the quality of vision that toric hydrogel lens wearers experience if an adaptation period is indeed necessary with every insertion.

CONCLUSION

Based on the clinical results of the established toric hydrogel lens wearer and the placement of a toric hydrogel lens on a nearly spherical cornea, it would appear that placement of toric hydrogel lenses on toric corneas are indeed creating a more spherical surface. However, the lack of sphericalization in non-established toric hydrogel lens wearers does not substantiate this hypothesis. The possibility of the existence of a significant tear lens effect in the non-established toric hydrogel lens wearers complicates the evaluation of the fitting of these lenses. As previously noted, the multiplicity of individual factors affecting the fit of toric hydrogel lenses makes it nearly impossible to find consistent, conclusive evidence regarding the mechanism by which the lenses correct corneal astigmatism. The questions raised about the quality of vision during a possible adaptation period upon insertion of the toric hydrogel lenses warrants further investigation.

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