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A clinical comparison of residual astigmatism produced by back surface aspheric hard lenses versus back surface spherical hard lenses

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Abstract

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A CLINICAL COMPARISON OF RESIDUAL ASTIGMATISM PRODUCED BY BACK SURFACE ASPHERIC HARD LENSES VERSUS BACK SURFACE SPHERICAL HARD LENSES

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David Richard Carlson
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INTRODUCTION

Residual astigmatism has been a problem commonly found in contact lens wearers. Various approaches have been used to deal with this problem. Some practitioners have used toric lenses, others have used front surface aspheric lenses in an attempt to optically mask the astigmatism.

This study was undertaken in an attempt to determine the effect that a back surface aspheric lens would have on the residual astigmatism.

The manufacturer of the experimental lens has made claims that it is sometimes helpful in reducing the residual astigmatism. The exact theoretical basis for this has not been clearly conveyed.

Our original hypothesis was that flexing of the lenses would account for some of this reduction as reported by Harris.[3] Harris also reported that lenses 0.13mm did not flex significantly on the cornea. The majority of experimental lenses were less than 0.13mm but a few were thicker and, therefore, a reduction in residual astigmatism with these lenses may require an explanation other than flexing.

LITERATURE SURVEY

Many investigators believe that residual astigmatism can be affected by flexing or warping of a thin spherical contact lens on a toric cornea. The basic theory underlying this is that the forces of lid pressure, adhesion and surface tension cause the thin lens to approximate the curvature of toric corneas.[1]

A lens with equal toricity on both surfaces induces a plus cylinder equal to the amount of lens flexure with axis along the flatter meridian.[2] Thin lenses will reduce residual astigmatism when residual astigmatisn with thick lenses and corneal toricity are in opposite directions. If residual astigmatism and corneal toricity are both with the rule or both against the rule the residual astigmatism will increase with a thin lens.[3]

Bailey believes the flexure to be about one-half the corneal toricity while Harris found it to be about one-fifth the corneal toricity.[4]

Bailey also believes that large lenses flex more than small lenses while Harris found no evidence of this.[5]

Harris found the major variables affecting lens flexure were center thickness and corneal toricity. While thick lenses ($CT > 0.13$mm) did not flex significantly on toric corneas. Thin lenses ($CT < 0.13$mm) did. With thin lenses on a given toric cornea, lens flexure and residual astigmatism increased, as center thickness decreased. For a given thin lens, the amount of flexure and associated residual astigmatism increased as the corneal toricity increased in a predictable manner. Harris presents a series of graphs to show these relationships.[6]

Westerhout found the flexure to be less predictable. Using lenses 0.1→0.14mm, he found that 14 out of 22 with the rule cases showed flexure of astigmatism with the rule but five cases showed flexure of astigmatism against the rule. He concludes that there was no real relationship between corneal astigmatism and the degree of flexure. He feels that the lid aperature has a great effect on the degree of lens flexure.[7]

Volz and Perrott found seven of fourteen eyes showed less absolute residual astigmatism with Flexinyl lenses (Breger-Mueller Welt Corporations ultra thin lens), than with conventional hard lenses. In six cases the absolute amount of residual cylinder remained the same and in only one case did the residual cylinder become more with the Flexinyl lens. Ten of fourteen eyes showed more with the rule with the ultra thin lens. Thus a conventional lens subject showing against the rule over refraction may be best helped with a Flexinyl lens. Their data also did not always agree with that of Harris in that more flexure was often found than predicted by Harris. For a 1.25 with the rule showed -.50 against the rule residual astigmatism using a conventional lens but no residual astigmatism using a flexinyl lens of .12mm center thickness.[8]

Harris took keratometer readings of the front surface of the contact lens to determine the amount of lens flexure. He found this to correlate very well with the change in residual astigmatism.[9] However, Westerhout cautions against using the keratometer to measure the flexure stating that to get mire alignment it is often necessary to ask the patient to open his eyes wide and immediately the results change due to a lessening influence of the lids on the degree of flexure.[10]

A thorough search of the literature has revealed no published studies dealing with back surface aspheric lenses and the effect on residual astigmatism.

METHODOLOGY

Subject Selection

Subjects were selected in order to obtain a variety of various types of corneal toricity. Corneal toricity ranged from 3.00 diopters with the rule to 2.00 diopters against-the-rule.

The spherical components of the subjects varied from .25 diopters to 7.25 diopters, with astigmatism ranging from -2.00 diopters with the rule to -2.75 diopters against the rule.

Both present contact lens wearers and noncontact lens wearers were accepted. The patient must have exhibited some type of problem with wearing contact lenses in the past. This criteria was included as a secondary part of the study as an attempt to learn what types of problems these lenses may be helpful in solving.

Subjects had to attend the arranged appointments for progress examinations and the collection of data.

Each patient selected was in good health and free from occular pathology.

The above criteria were determined by a case history, 21 pt. examination and biomicroscopy.

Method of Fitting Lenses

The following measurements were taken on each patient for selecting a lens of best fit: ophthalmometry, subjective refraction, fissure width, corneal diameter, pupil diameter, and lid tension. From these findings the contact lens laboratory chose the experimental lens of first approximation. With this lens further fitting observations were made and lens parameters changed to obtain what was felt to be the best possible fit.

The control lens with a spherical back surface was chosen to match the test lens in all parameters as closely as possible. Factors considered in selecting the control lens were: center thickness, overall diameter, base curve, and back vertex power. The only major difference between the test lens and the control lens was the fact that the test lens was a back surface aspheric lens with an eccentricity of .55 to .65 and the control lens was a spherical back surface. For the purpose of this study experimental lens refers to an aspheric back surface lens with an eccentricity of .55 to .65 manufactured by Berger Mueller Welt Corporation. The control lens refers to a bicurve spherical back surface lens from the Morrison fitting set.

Examination Procedure

1. The fit of the lens was judged by observation of lens position, movement, fluorescein evaluation and a general biomicroscope examination.

2. A spherical refraction was then performed over the experimental lens followed by acuities through the maximum plus to best visual acuity.

3. A spherical cylinder refraction was performed. The cylinder power and axis were refined by the standard Jackson Cross Cylinder using a 20/40 Snellen acuity row of letters. The sphere was the maximum plus to best visual acuity. Acuities were then taken through this lens.

4. Ophthalmometry reading were then taken over the contact lenses using the American Optical CLC ophthalmometer. This same instrument was used for all ophthalmometry readings.

5. The control lens was now placed on the eye and steps 2-4 were repeated with this lens in place.

6. With no lenses in place ophthalmometer readings were taken.

7. A post-refraction was then performed and acuities taken with this refraction in place.

Statistical Analysis Methods

A. To determine if there was any significant difference between the residual astigmatism as measured when wearing the experimental lens verses that measured while wearing the control lens. Three different statistical analysis methods were used.

1. Friedman analysis of variance for rank: This is a nonparametric method developed for use with correlated groups (or the same subject observed under different conditions.)[11]
2. Wilcoxen matched pairs signed ranks test: This is a nonparametric method that is more powerful than many methods because a large difference between a matched pair will receive more weight than a small difference.[11]
3. Sandler's A Test: This is a parametric method that is a variation of the student's "t" statistic developed for matched or correlated samples.

   Because the directionality of the results was not specified or known, a two tailed test criterion was utilized to determine the level of significance of the difference between the lens designs.[11]

B. To determine if there was a difference between ever K's with the two lens designs Sandler's A test was used.

C. Pearson product moment correlation coefficient was used to determine if there was a relationship between the amount of corneal toricity and the change in residual astigmatism between the experimental and the control lens.

D. Pearson product moment correlation coefficient was also used to determine if there was a relationship between the difference in over K's from control to experimental lens and the difference in astigmatism from control to experimental lens.

Table 1

SUMMARY OF SUBJECT SELECTION

Subject	eye	Initial "K" Readings	DK	Subjective
SH OD	1	44.12/47.12 @ 86	3.00 WTR	-2.50-2.00 x 180
SH OS	2	44.62/46.87 @ 104	2.25 WTR	-2.25-1.25 x 180
MD OD	3	43.50/45.75 @ 83	2.25 WTR	-4.75-2.00 x 180
MD OS	4	43.62/45.62 @ 94	2.00 WTR	-4.25-1.00 x 180
JR OS	5	41.37/43.25 @ 75	1.87 WTR	-7.25-1.75 x 150
JR OD	6	41.50/43.25 @ 103	1.75 WTR	-7.25-1.25 x 15
AR OS	7	41.50/42.50 @ 114	1.00 WTR	-1.50-1.00 x 70
AR OD	8	41.50/42.50 @ 75	1.00 WTR	-1.50-1.00 x 120
MS OS	9	42.50/43.25 @ 90	.75 WTR	-1.00-1.25 x 25
MS OD	10	42.87/43.00 @ 90	.12 WTR	-2.50 sph
BR OS	11	46.50/46.37 @ 105	.12 ATR	-2.00- .62 x 85
BR OD	12	46.00/46.62 @ 120	.62 oblique	-2.00- .62 x 85
SN OS	13	46.25/45.12 @ 74	1.87 ATR	-1.25-2.25 x 79
SN OD	14	46.75/44.75 @ 95	2.00 ATR	pl -2.75 x 91

Subjects eyes ordered from most WTR corneal toricity to most ATR Corneal toricity.

Table 2

RESULTS

A. Difference in measured residual astigmatism between control lens and experimental lens.

Subject eye	Residual Astigmatism Experimental	Control
1	.62W	.37W
2	.12W	.37W
3	1.00W	1.00W
4	0	0
5	.50A	0
6	.37A	0
7	.62A	.37A
8	.87A	1.12A
9	.50W	0 0
10	.250	0 0
11	.500	.750
12	.500	.500
13	.87A	1.00A
14	1.75A	1.75A

A- ATR Steeper @ 180 ± 30
W- WTR Steeper @ 90 ± 30
O- Oblique Steeper between 30 & 70 or 120 & 150

1. Friedman analysis of variance for ranks:
   No significant difference to the .05 level

2. Wilcoxen matched pair signed ranks test:
   No significant difference to the .05 level. The data tended strongly in the direction of more residual astigmatism with the experimental lens.

3. Sandler's A Test
   No significant difference to the .05 level. The data again tended in the direction of more residual astigmatism with the experimental lens.

Table 3

B. Difference between over K's with the experimental lens and the control lens.

Subject eye	Over K's Experimental	Control
1	1.00	.37
2	.87	1.00
3	1.12	1.00
4	.75	1.00
5	1.12	1.12
6	1.00	.62
7	0	0
8	0	0
9	1.00	.50
10	.25	.12
11	.25	0
12	.25	0
13	0	.37
14	0	0

1. Sandlers A test showed no significant difference between the two at the .05 level. The data tended toward more toricity over the experimental lens.

Table 4

C. Pearson product moment correlation between corneal toricity and the difference in residual astigmatism between the experimental and control lens.

Subject Eye	Corneal Toricity	Difference in Residual Astigmatism
1	3.00	.37
2	2.25	.25
3	2.25	0
4	2.00	0
5	1.87	.50
6	1.75	.37
7	1.00	.37
8	1.00	.25
9	.75	.50
10	.12	.25
11	.12	.25
12	.62	0
13	1.87	.12
14	2.00	0

r= -.1 This indicates essentially no correlation between corneal toricity and the difference in residual astigmatism.

Table 5

D. Pearson product moment correlation between the difference in over K's and the difference in residual astigmatism between the two lenses.

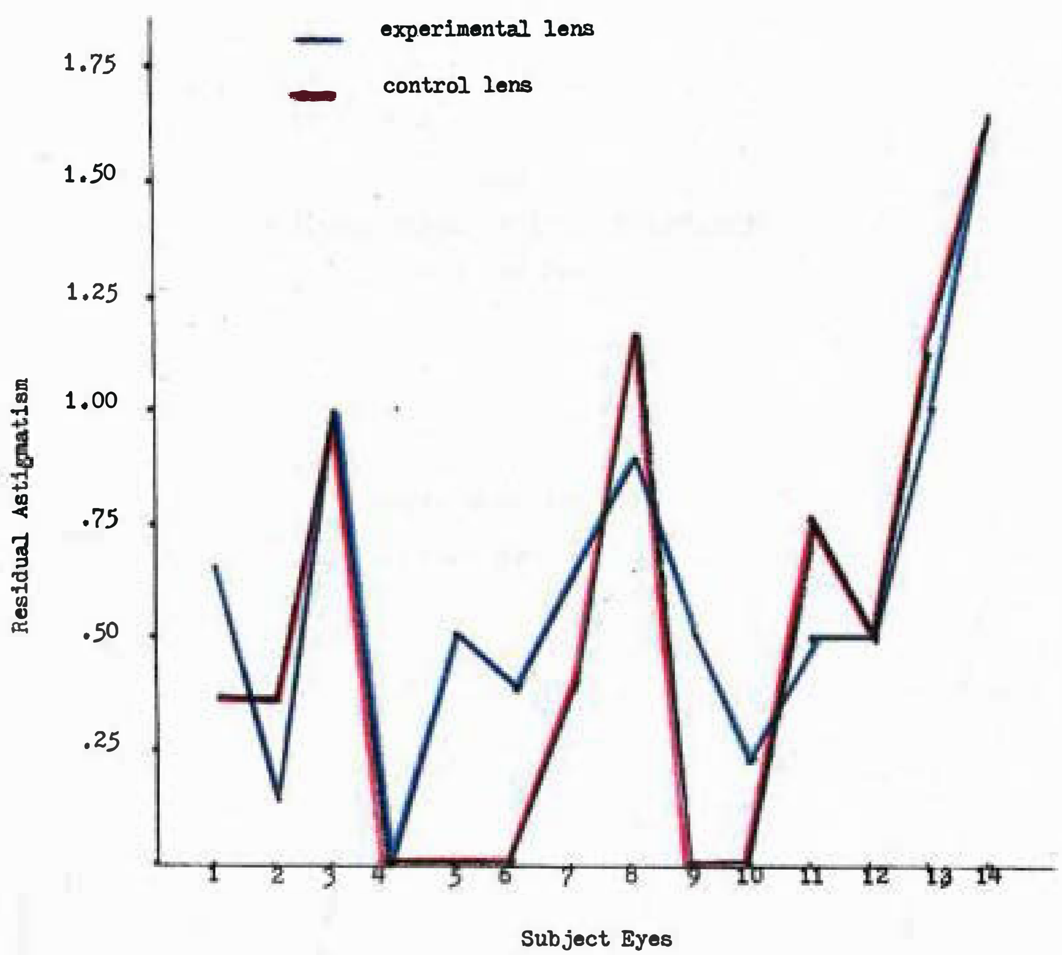
Subject Eye	Difference in over K's	Difference in Residual
1	.62	.37
2	.12	.25
3	.12	0
4	.25	0
5	0	.50
6	.37	.37
7	0	.25
8	0	.25
9	.50	.50
10	.37	.37
11	.25	.25
12	.25	0
13	.37	.12
14	0	0

r= .07 This indicates essentially no correlation between the difference in Over K's and the difference in residual astigmatism between the two lenses.

Graph 1

Residual Astigmatism Verses Subject Eyes

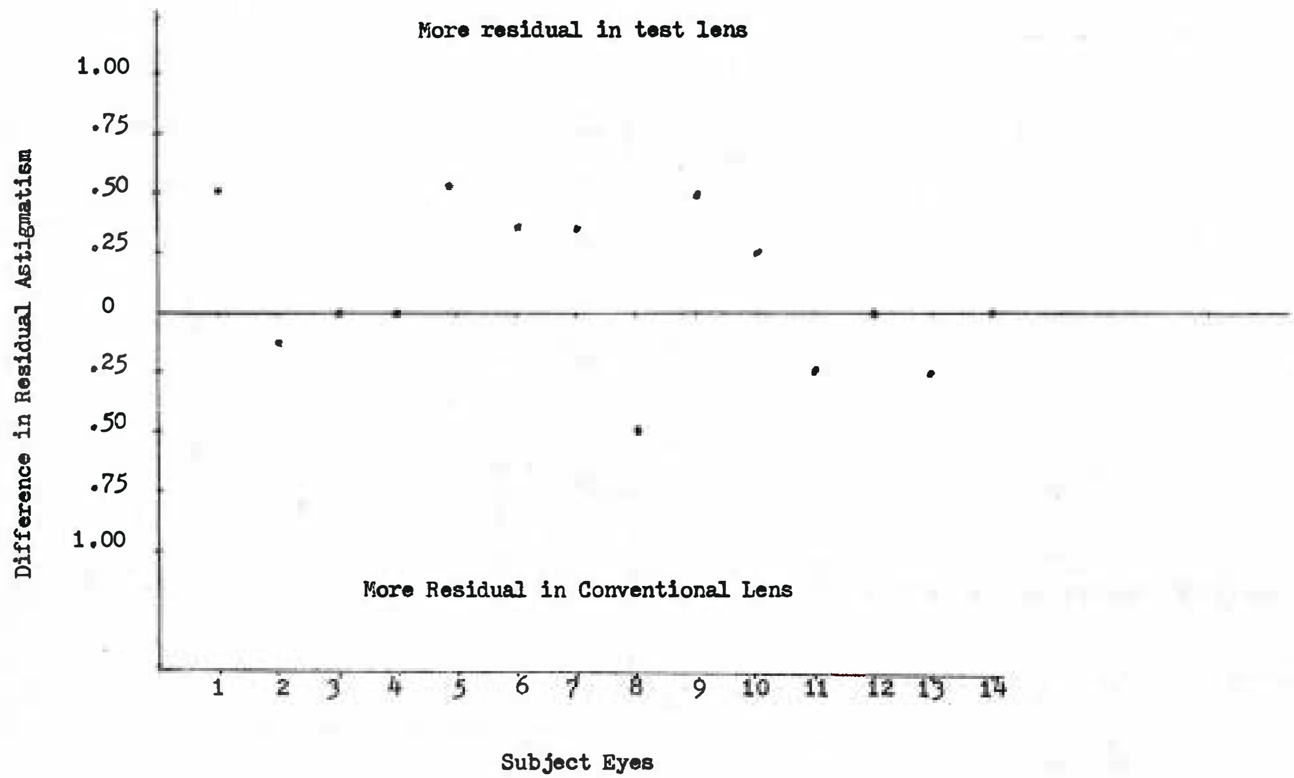
Data From Table 2



Graph 2

Difference in Residual Astigmatism Verses Subject Eyes

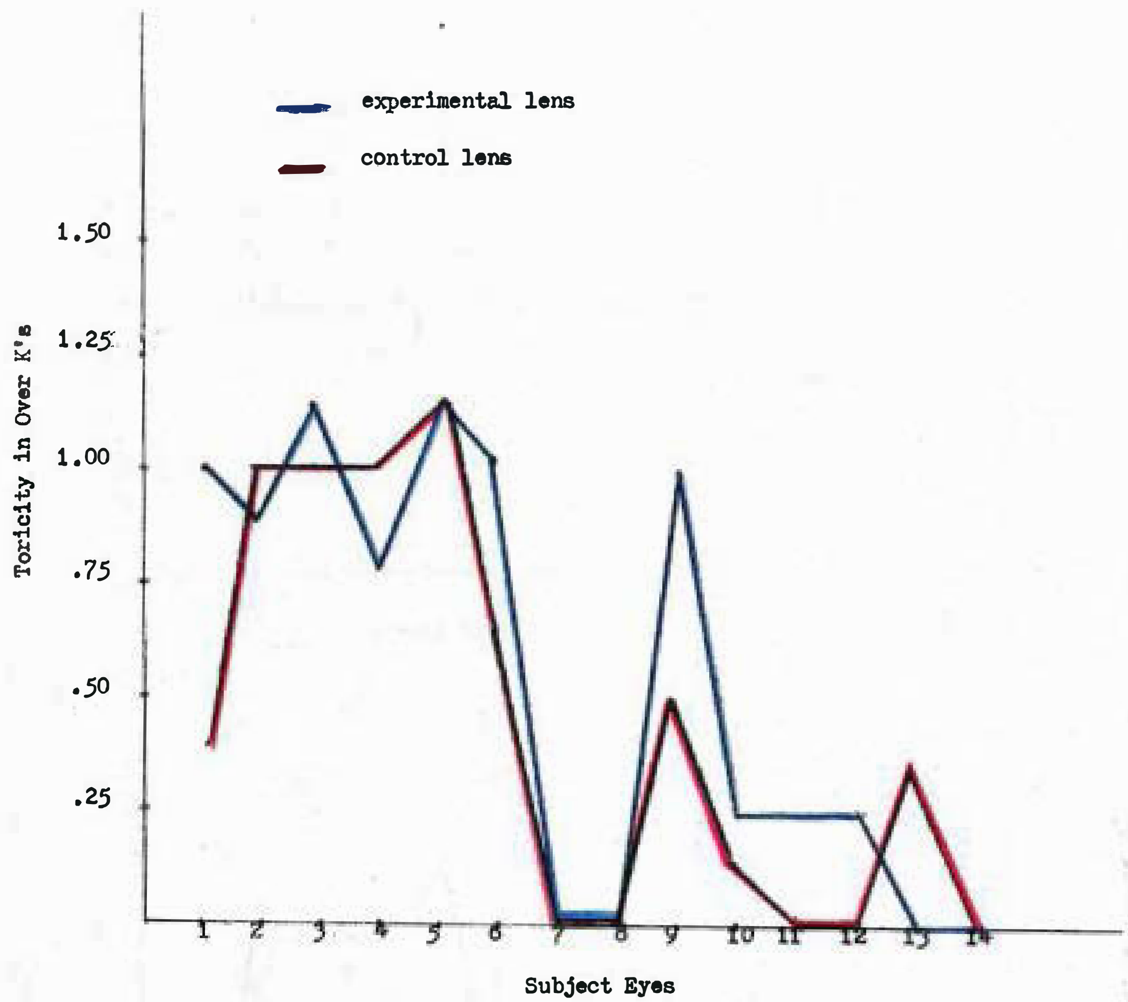
Data From Table 2 & 4



Graph 3

Toricity in Over K's Verses Subject Eyes

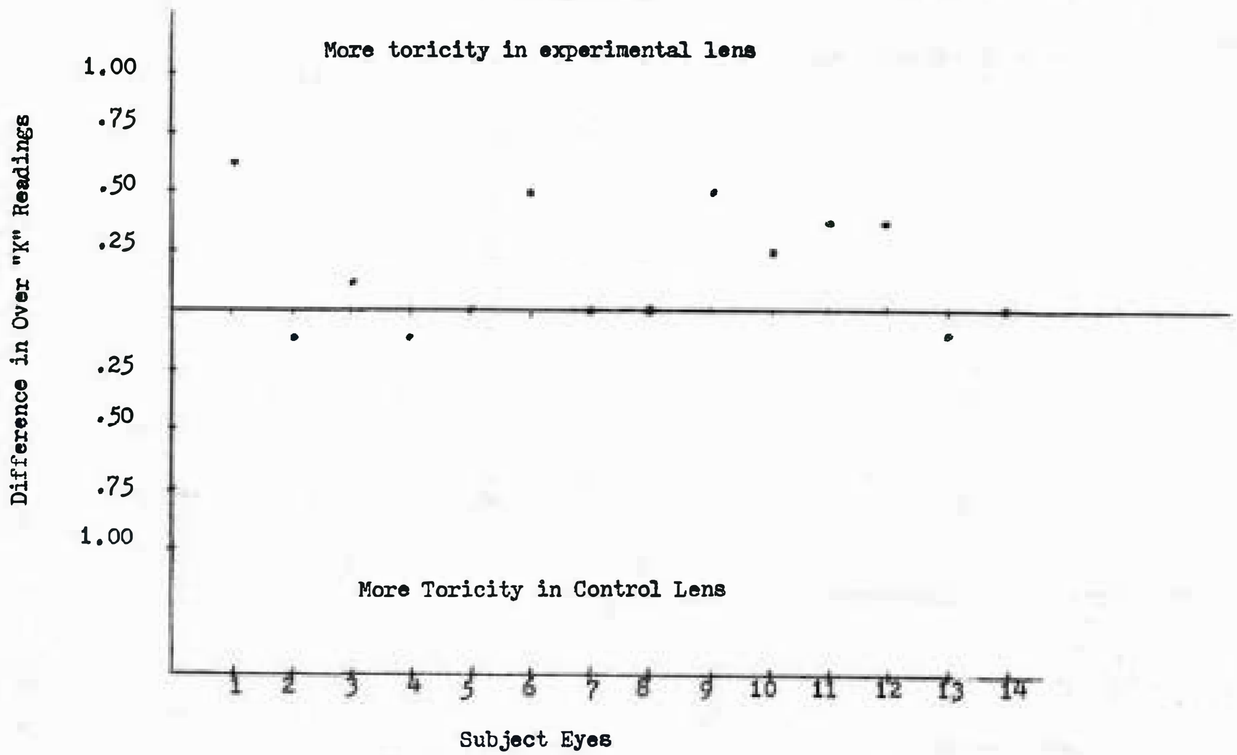
Data From Table 3



Graph 4

Differences in Over K's Verses Subject Eyes

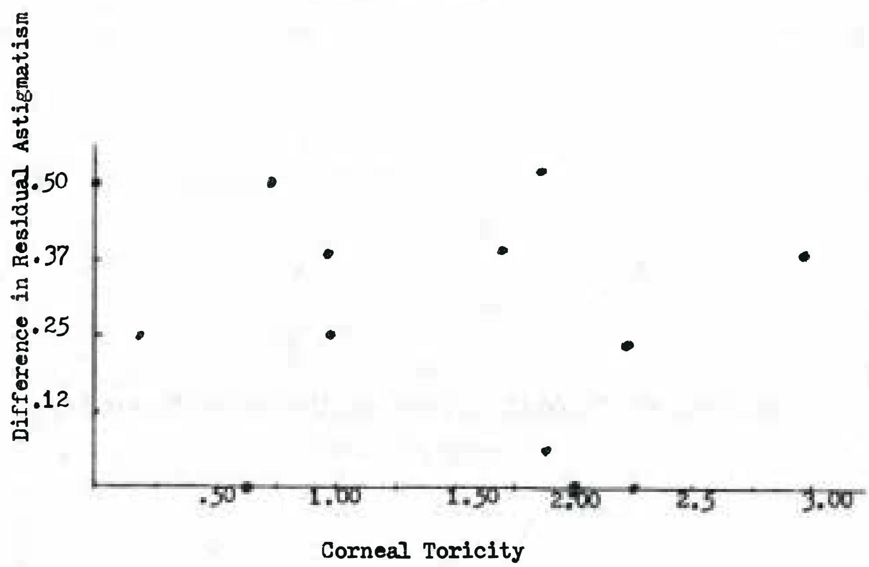
Data From Table 3



Graph 5

Difference in Residual Astigmatism Verses Corneal Toricity

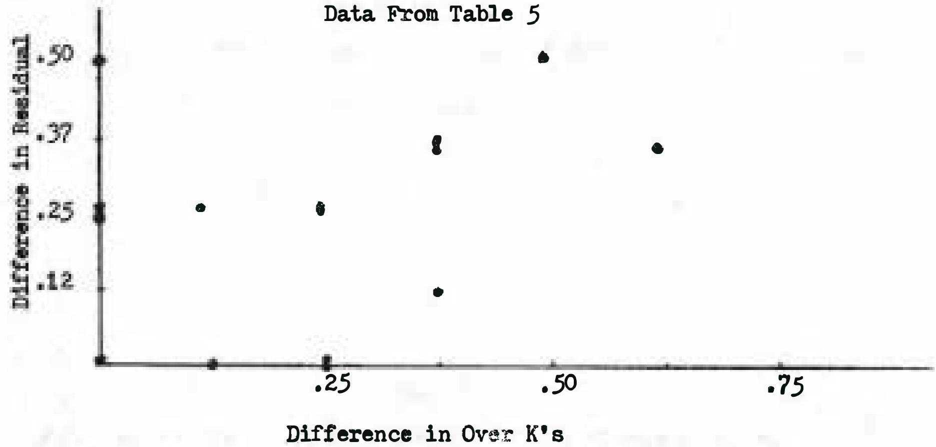
Data From Table 4



Graph 6

Difference in Residual Astigmatism Verses Difference in Over K's

Data From Table 5



Conclusions

No statistically significant relationships were found in this study. However, by examination of the graphs and data some tendencies can be sighted.

Although the difference in residual astigmatism between the two lenses is not significant at the .05 level there is a strong tendency in the data toward more residual astigmatism with the experimental lens and less with the control lens. (Graph 1 & 2) One possible explanation for this is that there is less flexing with the experimental lens than with the control lens.

This hypothesis is somewhat supported by the tendency in the data to show less toricity in the ever K's in the experimental lens than the control. (Graph 3 & 4) Again, this is not a statistically significant difference.

Lens flexure is generally thought to be due to the contact lens flexing to more closely match the shape of the cornea. Since the aspheric experimental lens already more closely matches the aspheric cornea than does the experimental lens one might expect that the experimental lens would indeed flex less on the eye.

No significant relationship could be found between the amount of corneal toricity and the amount of difference in residual astigmatism between the two lenses ($r = -.1$). This data is contrary to that given by Harris.[3] Westerhout, however, found that there was no real relationship between corneal astigmatism and the degree of flexure.[7] Our data seems to support Westerhout.

Possible reasons why there would be no relationship between corneal toricity and flexure include lid interaction and the different corneal topographies in the periphery. The fact that the aspheric lens tended to flex less and there was no correlation between corneal toricity and lens flexure would seem to indicate that lid interactions and peripheral corneal topography are more important than corneal toricity in determining the amount of flexure.

Further study with a larger number of subjects and possibly thinner lenses would be needed to determine if some of the above tendencies may be statistically significant.

A P P E N D I X

SUBJECT RELEASE FORM

1. Institution
   A. Title of Project: A study of the Effects of Lens Flexure on Residual Astigmatism
   B. Principal Investigators: Gary Christianson, David Carlson
   C. Advisor: T.J. Hohner, Lyn J. Coon
   D. Location: Forest Grove, Oregon
   E. Date: 1978-79

2. Description of Project
   This project will attempt to determine the difference in residual astigmatism produced by a standard thickness conventional lens verses a back surface aspheric Flexinyl Lens.

3. Description of Risks
   With any hard contact lens wear there is the possibility for statistically infrequent adverse side effects. These side effects may include irritation of the eye, mild patient discomfort, changes in shape of the optical elements of the eye, abrasion, conjunctivitis, keratitis, blepharitis, light sensitivity and other ocular irritations which would warrant the discontinuance of contact lens wear even in nonexperimental situations. The lens we are using, however, is not an experimental lens from the standpoint that it is available for standard contact lens fitting, but we are only investigating some aspects of its fitting and visual relationships to individuals eyes. Follow up examinations will be scheduled and the continuation of wear of these lenses will only be acceptable if successful contact lens wear is achieved under the normal criteria for any contact lens fitting.

4. Description of Benefits
   This project could give the contact lens world another tool in dealing with the problem of Residual Astigmatism.

5. Alternative Advantages to Subject
   This project will enable the subject to attempt a successful fitting of these flexinyl back surface aspheric lenses.

6. Offer to Answer Inquiries
   The examiner will be happy to answer any questions that you may have at any time during the course of the study.

Subject Release Form
Page 2

7. Freedom to Withdraw
   You are free to withdraw your consent and to discontinue participation in this project or activity at any time without prejudice to you.

I have read and understand the above. I am 18 years of age or over.

Signature________________________Date________________________

CONTACT LENS WORKUP

AGE: DATE:
PHONE:

ADDRESS:

KERATOMETRY

OD OS

SUBJECTIVE REFRACTION

OD OS

EYE COLOR:

FISSURE:
OD
OS

PUPIL DIAM:
OD
OS

CORNEAL DIAMETER:
OD
OS

LID TENSION:
OD
OS

SLIT LAMP EVALUATION

OD OS

PREVIOUS PROBLEMS:

PROGRESS EVALUATION

PATIENT: DATE:

WEARING TIME
MAX:
TODAY:

ACUITIES THROUGH C.L.
OD:
OS:
OU:

LENS POSITION
OD:
OS:

MOVEMENT
OD:
OS:

FLUORESCEIN EVALUATION
OD:
OS:

BIOMICROSCOPY EVALUATION
OD:
OS:

OVER REFRACRION
SPHERICAL
OD:
OS:

ACUITY

OVER REFRACTION WITH CONVENTIONAL LENSES
OD:
OS:

ACUITY

OVER K's
OD:
OS:

OVER K's THROUGH CONVENTIONAL LENSES
OD:
OS:

AFTER K's
OD:
OS:

POST REFRACTION
OD:
OS:

ACUITY

WEARING SCHEDULE

MAX HOURS WEAR DATE OF NEXT APPT.

OTHER

REFERENCES

[1]Harris, Michael G., "The Effect of Contact Lens Thickness and Diameter on Residual Astigmatism; a preliminary study, "Am J. Optom. and Arch. Am. Acad. Optom.," 47 (6); 442-444, 1970

[2]Harris, "The Effect of Contact Lens Thickness and Diameter on Residual Astigmatism" p. 444

[3]Harris, Michael G. and Chu Collin S., "The Effect of Contact Lens Thickness and Corneal Toricity on Flexure and Residual Astigmatism," Am J. Optom. and Arch. Am. Acad. Optom., April 1972, p 307

[4]Harris and Collin, p 444

[5]Harris and Collin, p 444

[6]Harris and Collin, p 444

[7]Westerhout, David L. "Contact Lenses: Corneal, Residual and Induced Astigmatism," International Contact Lens Clinic., Vol. 3, No. 3, (Sept./Oct. 1976), 57-58

[8]Voltz, William Bradley and Perrott, Richard, "The Application of Spherical Ultra Thin Flexinyl lense on the Toric Corneas, "Thesis Project Pacific University.

[9]Harris, "The Effect of Contact Lens Thickness and Diameter on Residual Astigmatism," p. 442

[10]Westerhout, p. 57

[11]Kolstoe, Ralph H. Introduction to Statistics for the Behavioral Sciences. Homewood Illinois: The Dorsey Press, 1973

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