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The influence of scribe mark pattern on perceived rotation of toric soft contact lenses

Abstract

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Committee Chair

Peter Bergenske

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The Influence of Scribe Mark Pattern on Perceived Rotation of Toric Soft Contact Lenses

By

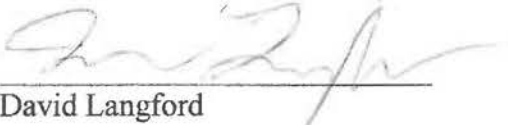
**David Langford
Marshall Palmer
Brook Walker**

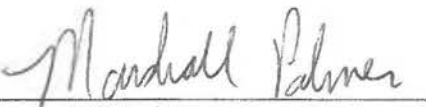
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Jennifer Smythe, O.D., M.S., F.A.A.O
Patrick Caroline, C.O.T., F.A.A.O

The Influence of Scribe Mark Pattern on Perceived Rotation of Toric Soft Contact Lenses

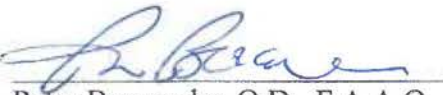
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Biography

David Langford is currently a fourth year student at Pacific University College of Optometry. He graduated from Ricks College with an Associate Degree in Arts and Sciences in 1997 and from Idaho State University with a Bachelor of Science in 1999. He met his lovely, charming, caring, and supportive wife during the first year of optometry school, and they are proud of their baby boy and another child will be arriving shortly. David lead a group called The Goatherders to win first place in the 2000 Opti-Rock talent show. For the past 2 years he has been a Sunday school teacher to 13-year-olds. He enjoys rollerblading, tinkering on his computer, and family time. He plans to establish a practice in the mountain states area, working 9-5 Monday-Friday.

Marshall Palmer was born and raised in Thatcher, Arizona where he worked with his father and brother on a family cotton farm. He earned his AS degree from Eastern Arizona College and attended the University of Arizona before receiving his BS degree in Visual Science from Pacific University. Marshall was awarded a three year Army Optometry Scholarship and will report for duty after graduation from Pacific University College of Optometry in May 2005. He has a lovely wife and two wonderful children who are a great support to him.

Brook Walker was born and raised in Montana. He attended Brigham Young University where he received his BS degree in Human Development in 2000. A life long dream was attained when he was accepted into the optometry program at Pacific University. Currently in his second year, optometry school has been challenging and rewarding. Upon graduation in 2005, he plans on returning to Montana to practice. Brook has been married to his sweet wife for four years, and they have two wonderful children.

Abstract

This study examined the effect of toric lens scribe mark designs on the perceived angle of rotation. Forty seven novice observers viewed video of 10 presentations for each of the seven lens designs. Overall, observers underestimated angles of rotation and no single lens design was more accurately estimated than any other. When horizontal vs. vertical lens designs were compared, the horizontal lenses were underestimated less than the vertical. Gender did not influence axis estimations.

Acknowledgments

We would like to thank Professor Jong Sung Kim, Assistant Professor of Statistics at the Portland State University Department of Mathematics and Statistics, for his invaluable help with the complicated analysis of the data.

We wish to acknowledge Vistakon's financial support. Vistakon supplied the toric lenses as well as funds which compensated the subjects and Professor Kim.

We also appreciate Sheila Hickson-Curran, BSc, MCOptom, at Vistakon. She was the real inspiration on this project.

Finally, we are very grateful for our wives who kept a good supply of brownies, strawberry pie, and doughnuts while we worked late into the night. They were our motivation and encouragement.

Introduction

Assessment of on-eye lens rotation is a key element in toric soft contact lens prescribing. A maloriented toric soft contact lens induces undesirable astigmatic effect and corresponding compromise of visual acuity.¹²³ Induced astigmatic error is directly proportional to both the degree of axis mislocation and the cylinder power in the lens. Clinical practice requires the practitioner to either measure or estimate the degree of rotation and to note the direction (clockwise vs. counterclockwise). Most often this information is used to simply select a lens cylinder axis that is corrected for the rotation.

Given that toric soft lenses are rarely available in axis increments less than five degrees, and that cylinder power is typically less than 2.00 D, many, if not most practitioners find it satisfactory to rely on estimation rather than precise measurement of axis rotation. Different brands of lenses have varying types and orientations of scribe markings to indicate a reference point for rotation. It is possible that practitioners making the estimation may be biased by the placement and style of markings, similar to effects seen in the rod frame illusion.⁴ This bias may lead one to judge a given lens design to rotate “a great deal” or “slightly”.

The purpose of this study was to determine whether, and to what degree, scribe mark design and location influence clinical estimation of lens rotation on the eye. The study was designed to see if:

1. There is a particular lens design that is estimated more accurately.
2. Horizontally placed scribe marks are judged similar to vertically placed marks.
3. There is a significant gender difference in making these judgments.

A somewhat similar study on rotational position of toric soft contact lenses was conducted by Snyder and Daum.⁵ The study consisted of 14 (12 male and 2 female) experienced contact lens practitioners that judged rotational position of four differently marked lenses presented on still photographs.

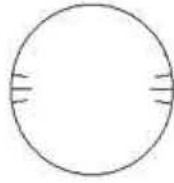
This study is different than the previously mentioned study in that it utilized:

1. A larger population of viewing subjects with near equal numbers of men and women.
2. Dynamic video rather than static photo presentations of the lenses.
3. A circular mat around the viewing monitor to hide reference points.
4. Novice observers as subjects.
5. Seven different toric lens designs.

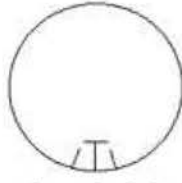
Materials and Methods

For this study seven toric lenses with different marking patterns were provided. The lenses employed were:

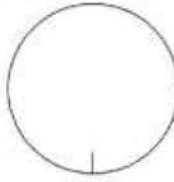
- Acuvue Toric with crow's feet at 3 and 9 o'clock positions with 10 degree separation.



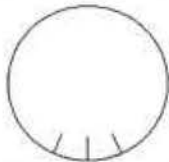
- Freshlook Toric with crow's feet at 6 o'clock with a horizontal line above the crow's feet.



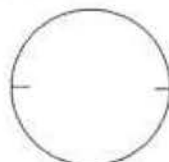
- Procon with a single scribe mark at 6 o'clock



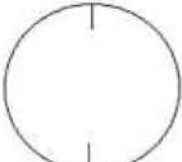
- Softlens 66 with markings at 6 o'clock and 30 degrees on either side.



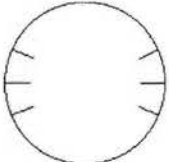
- Vistakon experimental 3 and 9 (single marks at 3 and 9 o'clock)



- Vistakon experimental 6 and 12 (single marks at 6 and 12 o'clock)



- Vistakon experimental crow's feet at 3 and 9 o'clock with 30 degree separation.



Lenses of each type were placed on an eye and a video image was captured of the appearance of the lens with slit-lamp illumination. Video was sent from the slit lamp camera to a digital-8 camcorder via S-video cable. By manual manipulation of the lens, a variety of rotational positions were created and recorded for each lens design. The recordings were edited to create ten 15 second video clips of each lens at a variety of orientations. Thus, there were a total of seventy 15 second video clips. These were edited digitally, placed in random order, and then transferred to VHS tape for viewing on a television monitor. Video was chosen over still photo because it is more comparable to true clinical observation. Video was chosen over live presentation to ensure that all subjects observe identical presentations. The television monitor was framed with a large circular mat intended to keep the outer rectangular frame from influencing judgment of orientation (see Appendix A). The television monitor was placed 10 feet in front of the observers and elevated slightly above eye level. No more than three observers were placed in front of one monitor. The total video time was 25 minutes with a visual hygiene break consisting of looking at least 20 feet away for 30 seconds mid way through the presentation.

Forty-seven novice observers (25 male and 22 female) viewed the lenses and responded by recording on paper their estimate for degree of rotation. These novice observers were third and fourth year optometry students who had completed their didactic and laboratory courses in contact lenses but have limited clinical experience with contact lenses. Participants were reminded that one clock hour represents thirty degrees rotation. Observers were instructed to make estimates in 2-3 degree increments. The responses were compared to the actual rotation as measured directly on the monitor with a protractor and straight edge.

The subjects' written responses for degree of rotation were then compiled and transferred onto an Excel spreadsheet in preparation for statistical analysis.

Results

We used a convention that subjects were to indicate a clockwise rotation with a "-" and a counter clockwise one with a "+". There were a number of observers who had reversed a sign. We did not think they could really be seeing it that way, and so we appropriately modified these cases. We excluded a subject's whole responses from our analysis because the subject had either too many errors or unanswered responses.

We will separate our results into two parts. Part I will analyze the individual lenses against the other lenses. Part II will analyze the data into groupings of lenses based on scribe mark orientation (horizontal vs. vertical).

Data Analysis Part I

Overall Mean Difference:

First we looked at the difference between the mean of observers' estimations of rotation and true mean rotation. Difference is determined as the absolute value of the true rotation less the absolute value of the mean estimated rotation, thus an underestimation returns a positive number.

$$|true| - |estimated| = difference$$

The following histogram shows that the mean difference looks greater than zero.

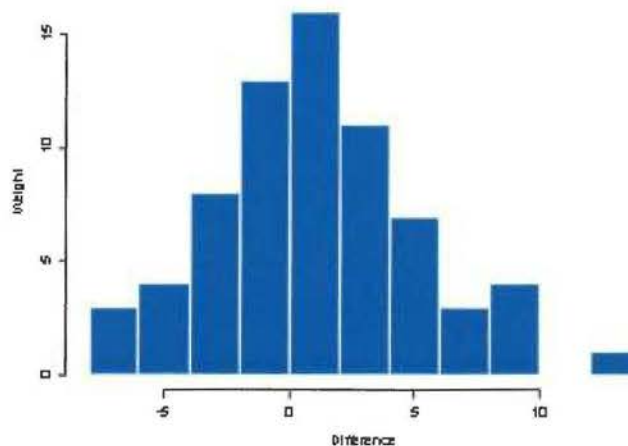


Figure 1. Mean difference vs. number of presentations

A one-sample t-Test was applied to determine if the difference we observe between true axis and estimated axis is statistically significant. The difference was found to be significant to the 95% confidence interval, and thus *we conclude that there is a statistically significant difference between observers' estimated mean and the true axis.* Furthermore, overall, *observers underestimate angles of rotation.*

Type-Specific Mean Difference:

Next we looked at mean differences for each specific lens type. The following Figure makes it appear that there is a relatively large difference between the results for the Procon and Soflens 66, and the Vistakon 3-9 single (Figure 2).

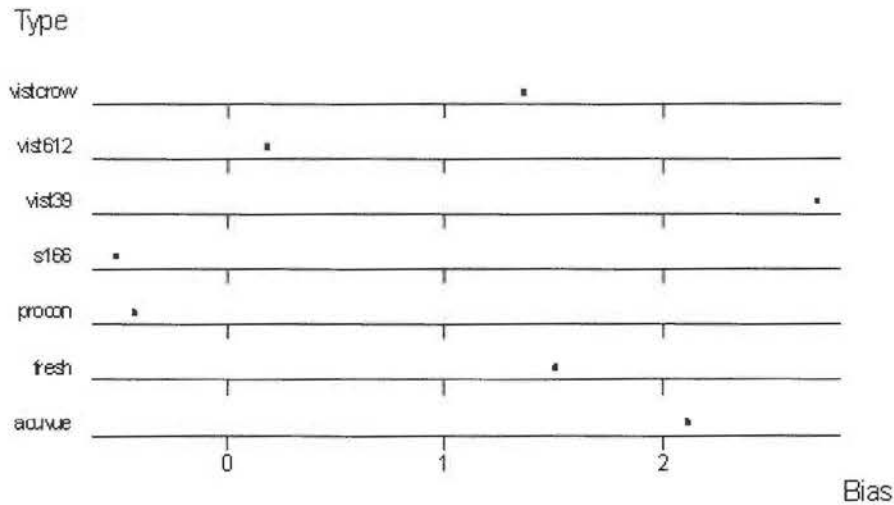


Figure 2. Users Bias in Estimation of Rotation by Lens Type

We applied a one-way analysis of variance method to see if there was a statistically significant difference among types. The results lead us to conclude that *there is no statistically significant difference among types* ($p=.467$). See also the following simultaneous confidence intervals. None of them are totally apart from the rest (Figure 3). This also supports our conclusion.

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
Acuvue Toric	10	2.115	4.948	(-----*-----)
Freshlook Toric	10	1.515	1.847	(-----*-----)
Procon	10	-0.422	4.082	(-----*-----)
Softlens 66	10	-0.503	2.848	(-----*-----)
Vistakon 3-9 single	10	2.707	3.402	(-----*-----)
Vistakon 6-12	10	0.189	5.838	(-----*-----)
Vistakon crow 3-9	10	1.362	4.284	(-----*-----)
Pooled StDev = 4.082				-----+-----+-----+-----+-----
				-2.5 0.0 2.5 5.0

Figure 3. Confidence Intervals for Mean Bias by Lens Type

Overall Gender Bias:

The following figure shows that there is not a substantial difference between males and females.

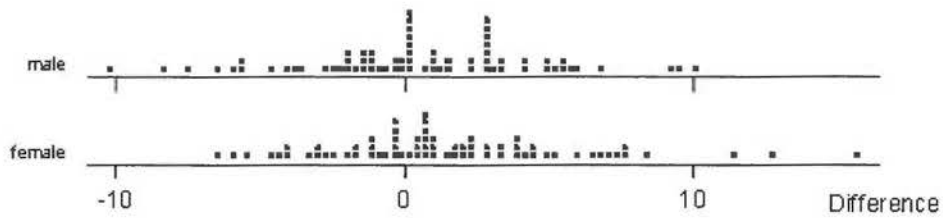


Figure 4. Differences Between True and Mean Estimated Rotation by Gender

The distributions are approximately the same shape, though the male distribution is slightly to the left of the female distribution. In other words, men underestimate to a slightly lesser degree than women; however, a two sample t-Test confirmed *there is no difference between males and females in their ability to estimate angles.*

Type-Specific Gender Bias:

When we look at gender bias by specific lens type, we find males estimate angles larger than females do for all types but Vistakon 3-9 single and Freshlook Toric. We also notice that there is a difference between Vistakon 6-12 and Vistakon 3-9 single. See the following multiple dot plot in figure 5.

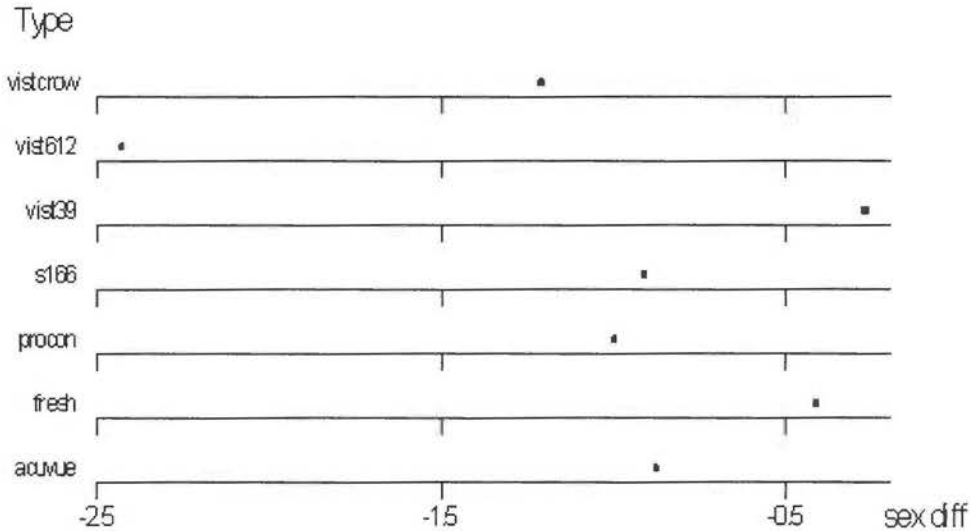


Figure 5. Gender Bias in the Estimation of Rotation by Type.

We applied a one-way analysis of variance method to see if there was a statistically significant difference among types and conclude that *there is no statistically significant*

For the following histogram the differential is determined by the Group B difference subtract the Group A difference, thus a smaller difference for Group A yields a positive number. The following histogram shows that the distribution of the differential has a strictly positive mean, and it is slightly skewed to the left.

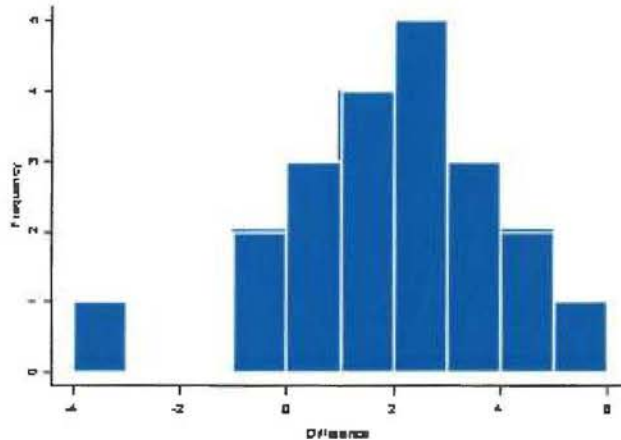


Figure 7. Differential between Group A and B differences for Female Observers

We applied a paired t-Test to see if there is a significant difference between groups A and B for females. The results were as follows: $t = 4.4176$ with degrees of freedom being 20, $p\text{-value} = 0.0003$, a 95 percent confidence interval (1.035690, 2.888825), and the mean of the differences being 1.962257.

Since the $p\text{-value}$, 0.0003, is less than the significance level, 0.01, we conclude that there is a strong significant difference between two types of markings. Note that the 95 percent confidence interval excludes zero and thus this also confirms that the mean of the differences is not zero. In summary, *Group A causes a female individual a larger estimation of an angle of rotation when compared to Group B*, which implies that for a female, the estimate of an angle of rotation will be larger when one observes a lens with horizontal marking on it.

The Effect of Different Types of Markings among Males:

In this case, we apply paired t-Test to see if there is a significant difference between groups A and B for males. The following histogram shows that the distribution of the differences has a strictly positive mean (clearly larger than that within females), and it is a little skewed to the left (figure 8).

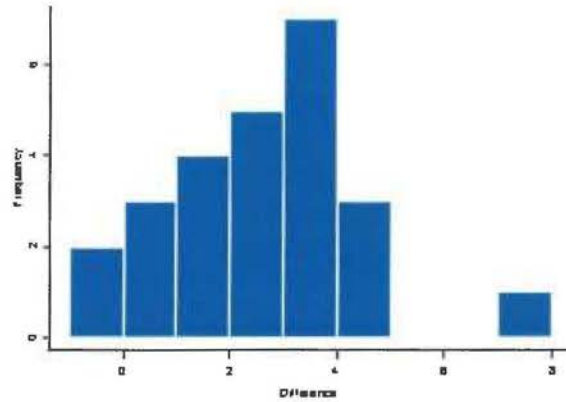


Figure 8. Difference between Group A and Group B for Male Observers

A Paired t-Test indicates $t = 7.2912$ with degrees of freedom being 24, $p\text{-value} = 0$, a 95 percent confidence interval (1.868327, 3.343673), and the mean of the differences being 2.606.

Since the $p\text{-value}$, zero, is less than the significance level, 0.01, we conclude that there is a strong significant difference between two types of markings. Note that the 95 percent confidence interval excludes zero and thus this also confirms that the mean of the differences is not zero. In summary, *Group A causes a male individual a larger estimation of an angle of rotation when compared to Group B*, which implies that for a male the estimate of an angle of rotation will be larger when one observes a lens with horizontal markings.

The Effect of Different Types of Markings Without Regard to Gender:

The above results lead us to believe that there must be a strong significant difference between the two groups of markings since each case has a strong positive difference. However, we have to go through the steps again to match our conjecture and the actual result.

In this case, we apply a paired t-Test to see if there is a significant difference between groups A and B without regard to gender. The following histogram shows that the distribution of the differential has a strictly positive mean and is still slightly skewed to the left (figure 9).

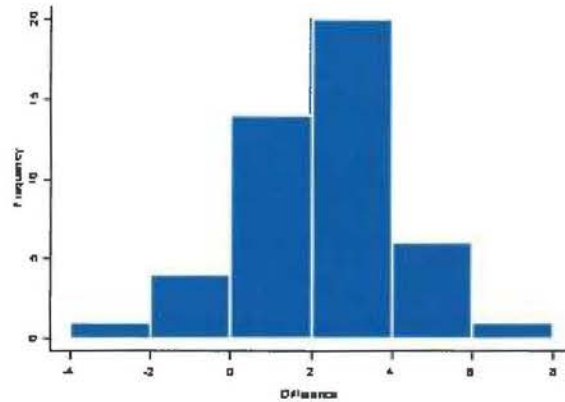


Figure 9. Differential between Groups A and B for All (Male and Female) Observers

A Paired t-Test was applied. A summary of the test includes $t = 8.2082$ with degrees of freedom being 45, $p\text{-value} = 0$, a 95 percent confidence interval (1.744776, 2.879459), and the mean of the differences being 2.312118.

Since the p-value, zero, is less than the significance level, 0.01, we conclude that there is a strong significant difference between two types of markings without regard to gender. Note that the 95 percent confidence interval excludes zero and thus this also confirms that the mean of the differences is not zero. In summary, *Group A shows a larger estimate of the angle of rotation than Group B.* This implies that the estimate for an angle of rotation will be larger when one observes a lens with a horizontal marking on it.

The Effect of Different Types of Markings between Females and Males:

As previously discussed, there is a strong significant difference between the two types of markings for each gender. Our interest also lies in the degree of difference between females and males.

The female group and the male group are independent of each other. In this case, we applied a Two-Sample t-Test to see if there is a significant difference between females and males. We have already seen a histogram for each group. (See histograms in figures 8 and 9.) The two histograms seem to have much in common, particularly in the range of zero to four.

We applied a Two-Sample t-Test. A summary of the test includes $t = 1.3357$ with degrees of freedom being 50, $p\text{-value} = 0.1877$, a 95 percent confidence interval (-0.4695823, 2.3339477), and the mean of female group being 1.505516 and mean of male group being 0.5733333.

Since the p-value, 0.1877, is much larger than the significance level, 0.05, *we conclude that there is no significant difference between females and males magnitude of estimation.* Note that the 95 percent confidence interval includes zero. This also confirms that the two group means are the same.

Error in Rotation Estimation With Increasing Amount of True Rotation

Individual Lens Types:

We plotted the mean and standard deviation of the estimates of rotation for each of the lens types as a function of the amount of true rotation (figures 10-16). It is not surprising that the amount of error tends to increase with the amount of rotation. For most lens designs observed, there was a tendency for increasing under-estimation of the angle with increasing true rotation (slope of trendline between 0 and 1). An exception to this was the Acuvue Toric (slope of trendline >1), which shows a tendency toward greater over estimation with increased true rotation (figure 10).

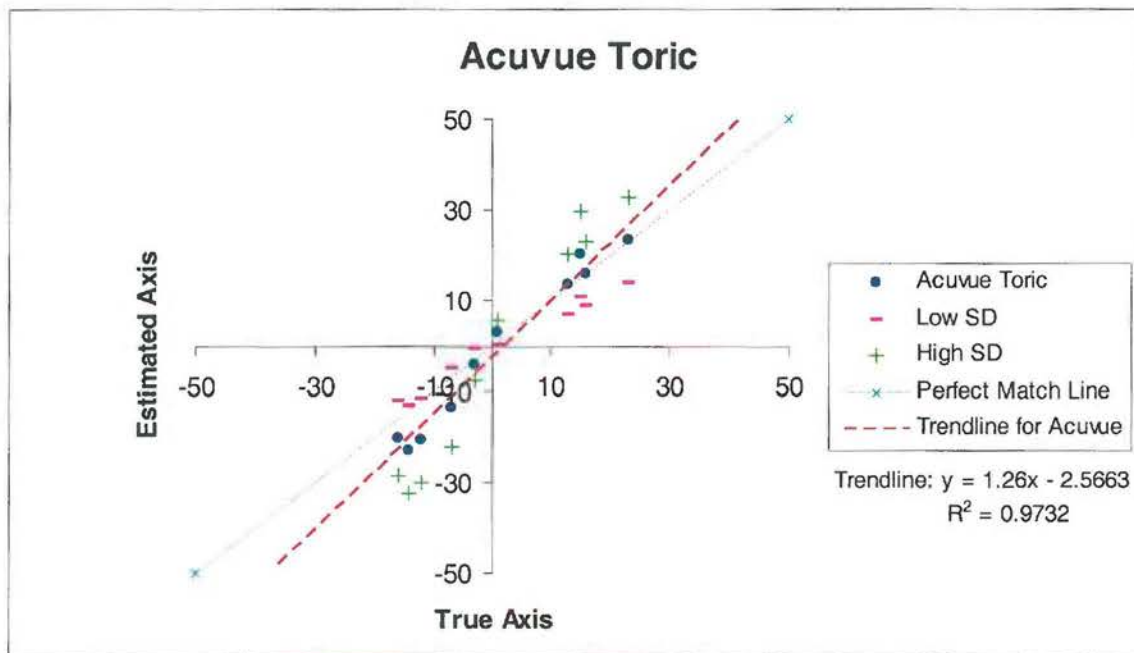


Figure 10. Plot of True vs. Estimated Axis with Trendline for Acuvue Toric

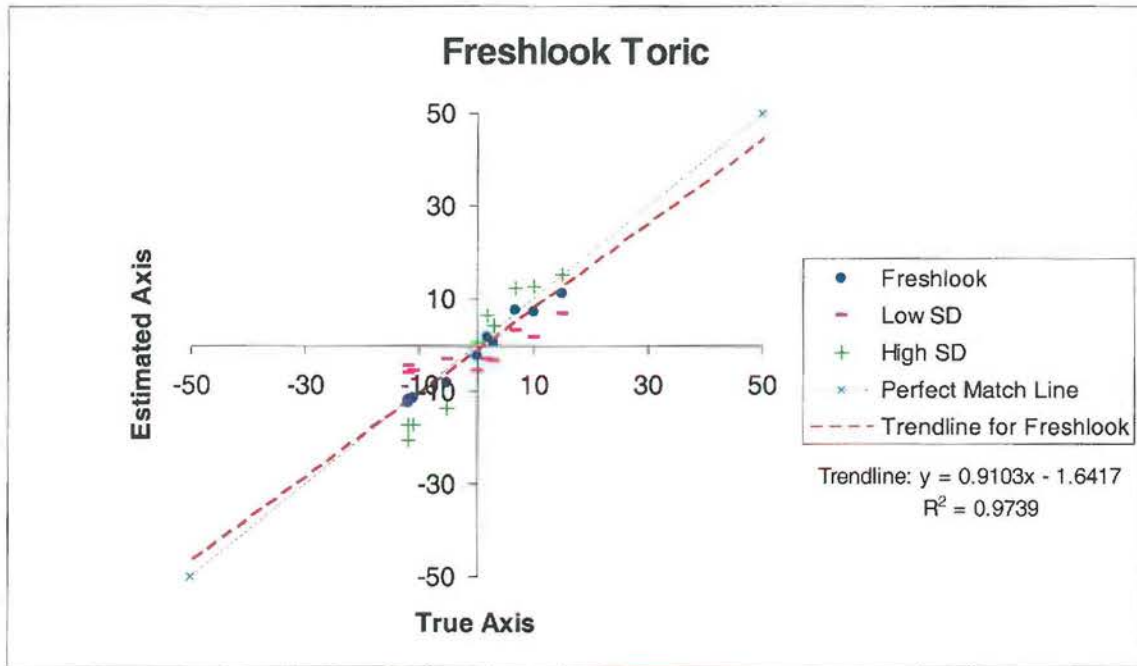


Figure 11. Plot of True vs. Estimated Axis with Trendline for Freshlook Toric

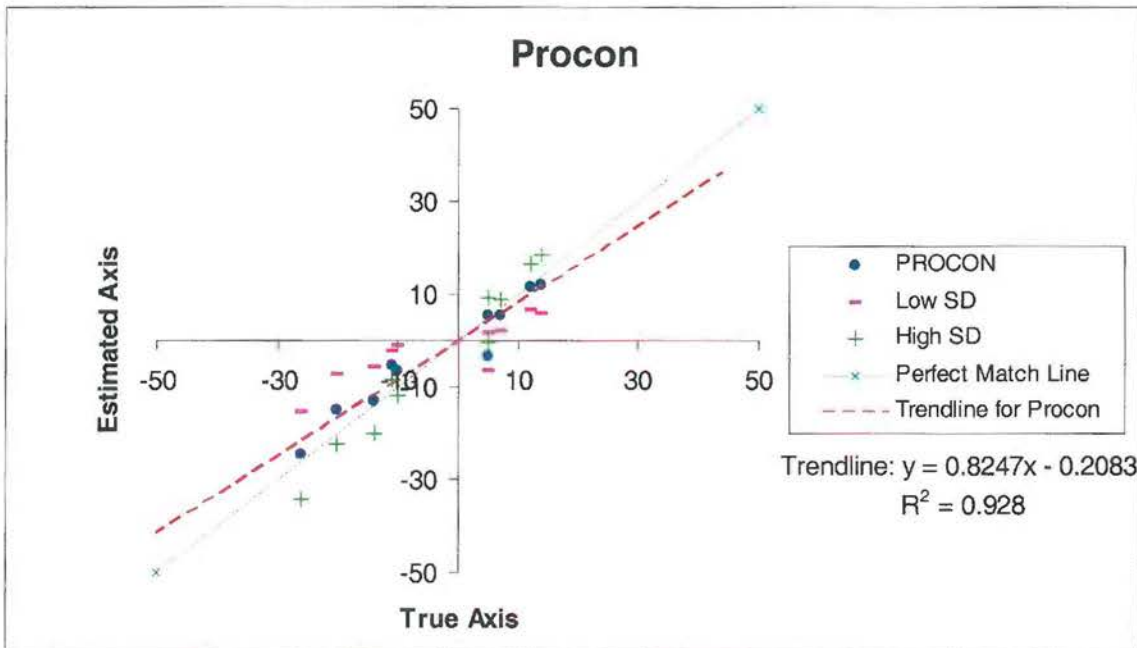


Figure 12. Plot of True vs. Estimated Axis with Trendline for Procon

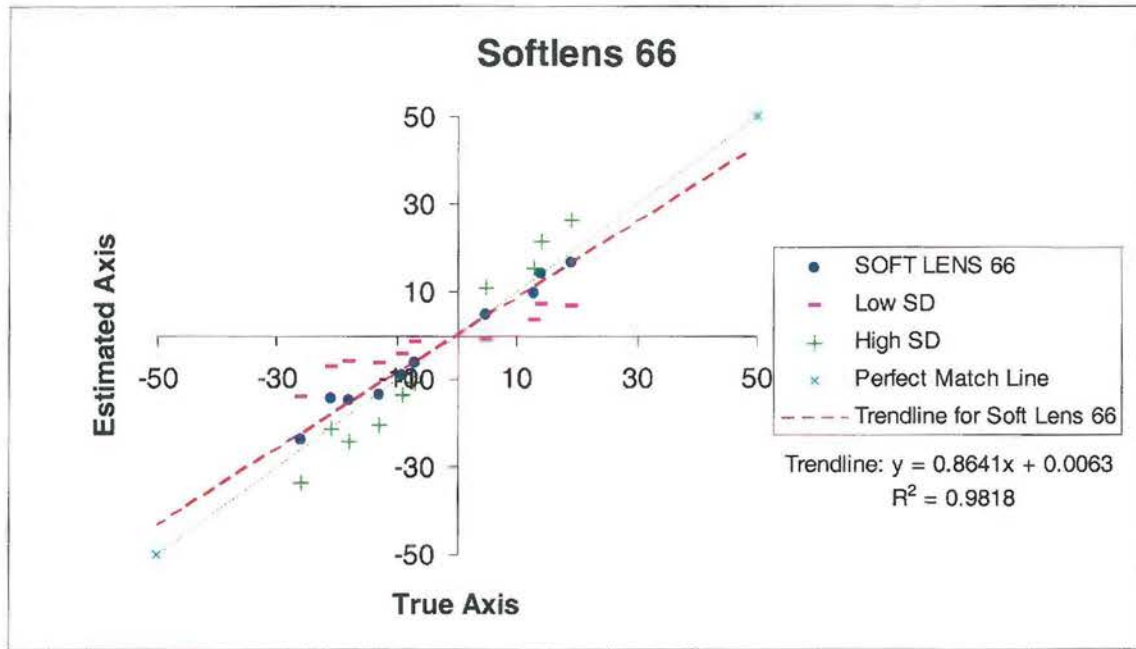


Figure 13. Plot of True vs. Estimated Axis with Trendline for Softlens 66

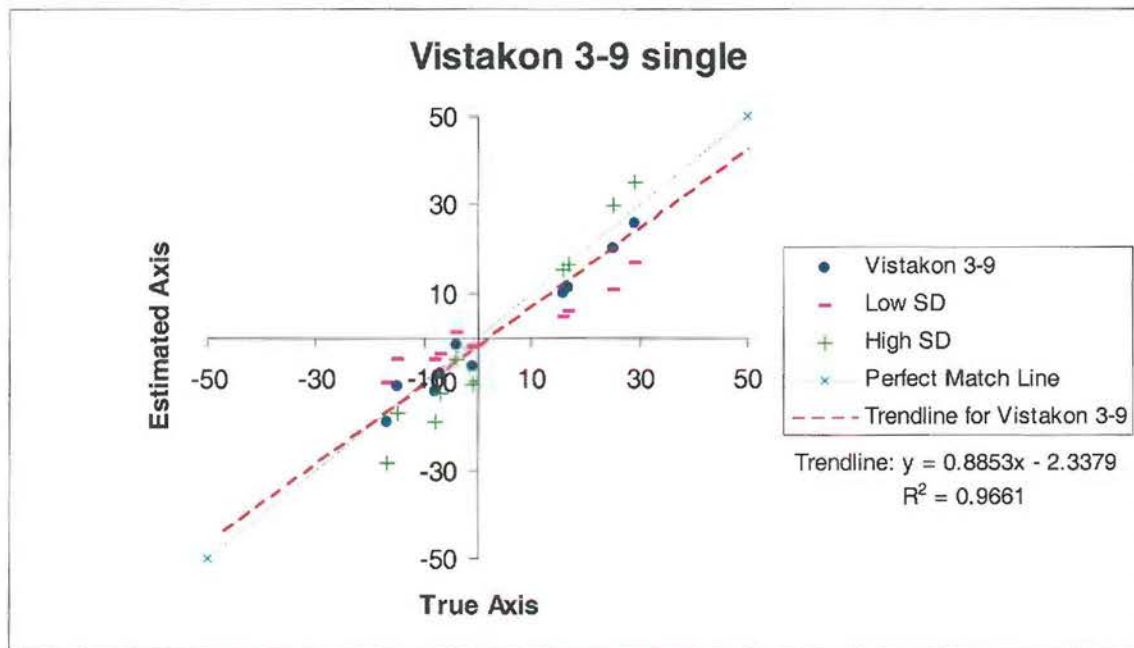


Figure 14. Plot of True vs. Estimated Axis with Trendline for Vistakon 3-9 single

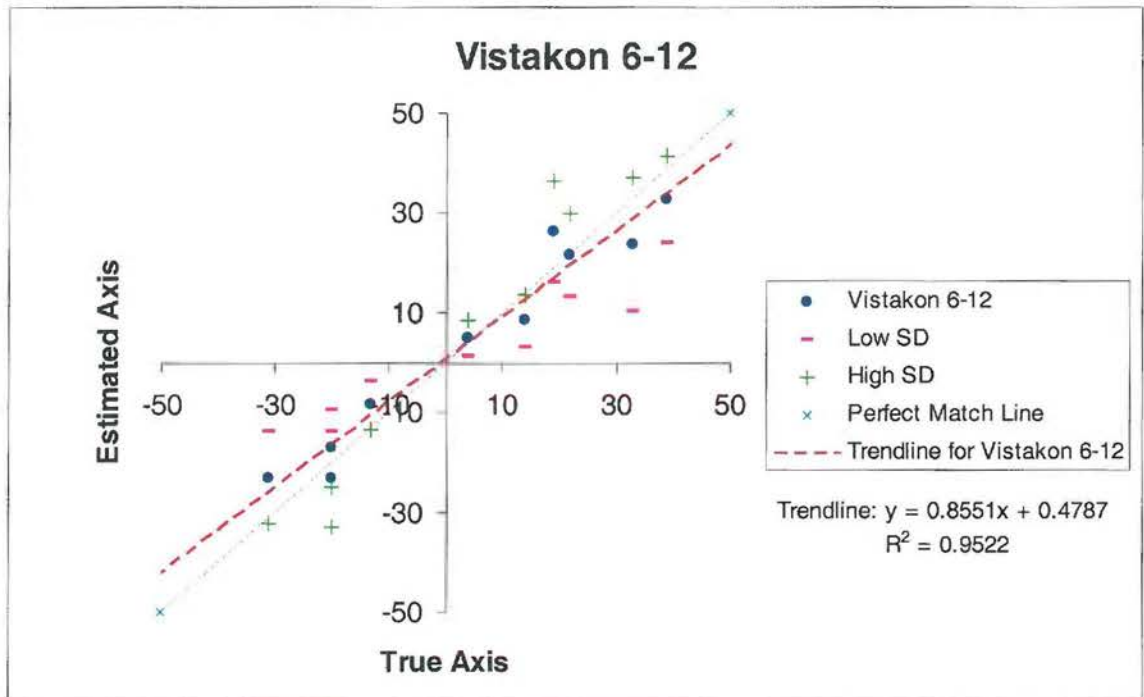


Figure 15. Plot of True vs. Estimated Axis with Trendline for Vistakon 6-12

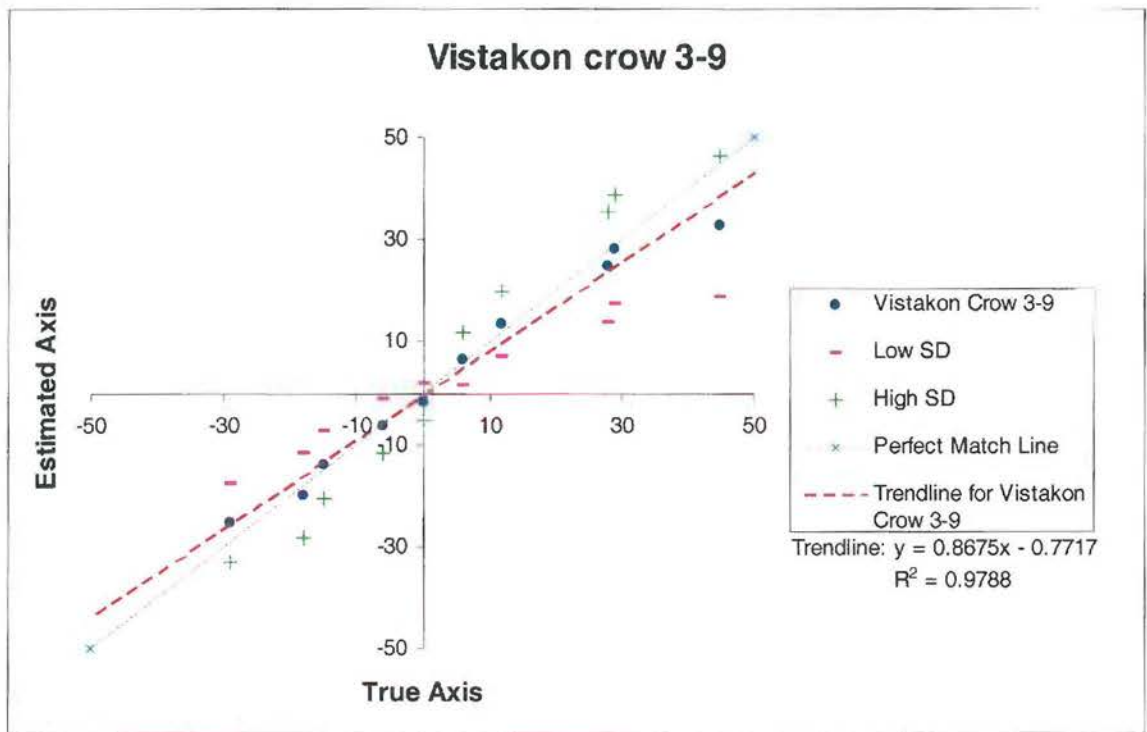


Figure 16. Plot of True vs. Estimated Axis with Trendline for Vistakon crow 3-9

A summary of the over and under estimation for each lens type is represented in figure 17. Again, positive values represent underestimation of the angle. It also shows that in general, observers tend to underestimate the angle of lens rotation.

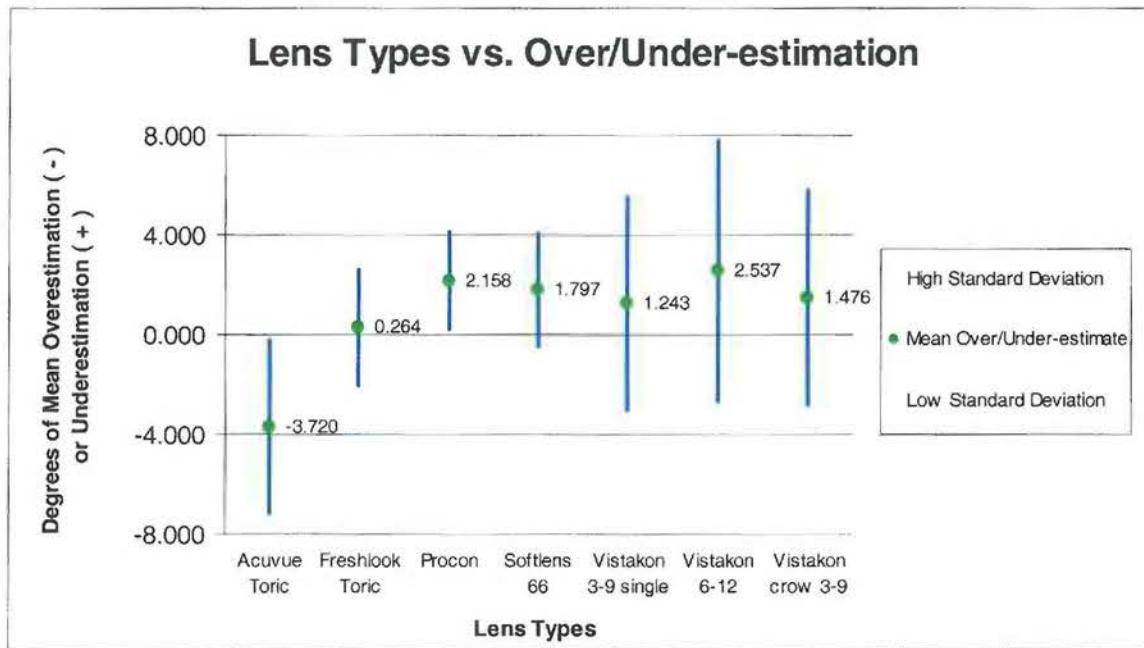


Figure 17. Lens Type vs. Degree of Mean Estimation

Horizontal versus Vertical Markings

We plotted the mean and standard deviation of the estimates of rotation for lenses grouped into “A” (horizontal markings) and “B” (vertical markings) as a function of the amount of true rotation. Figures 18 and 19 display the trends for the two groups.

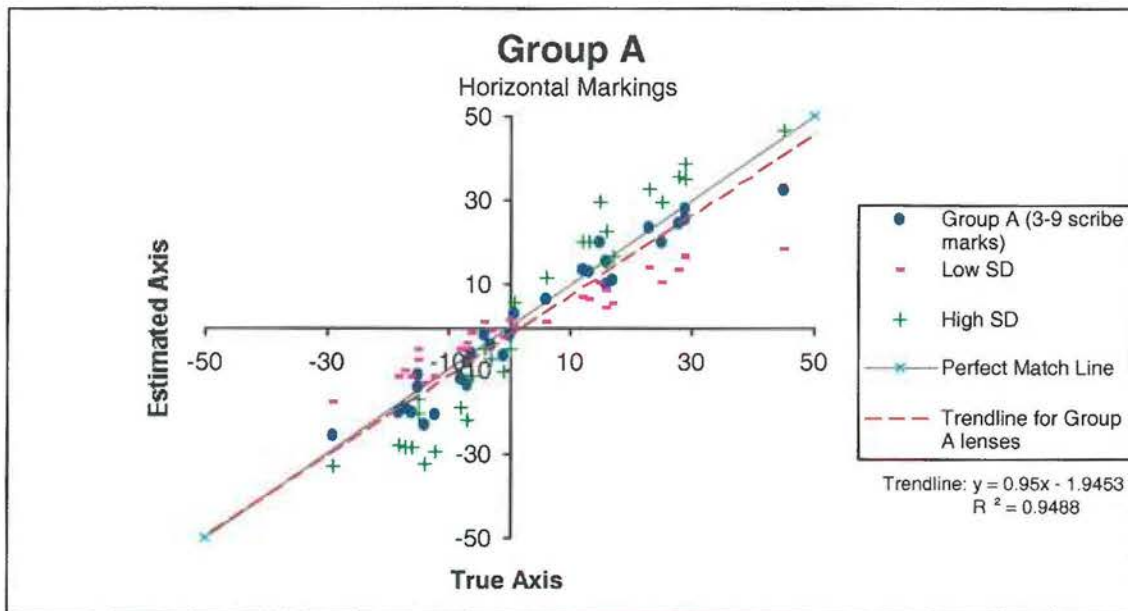


Figure 18. Plot of True vs. Estimated Axis for Group A Lenses

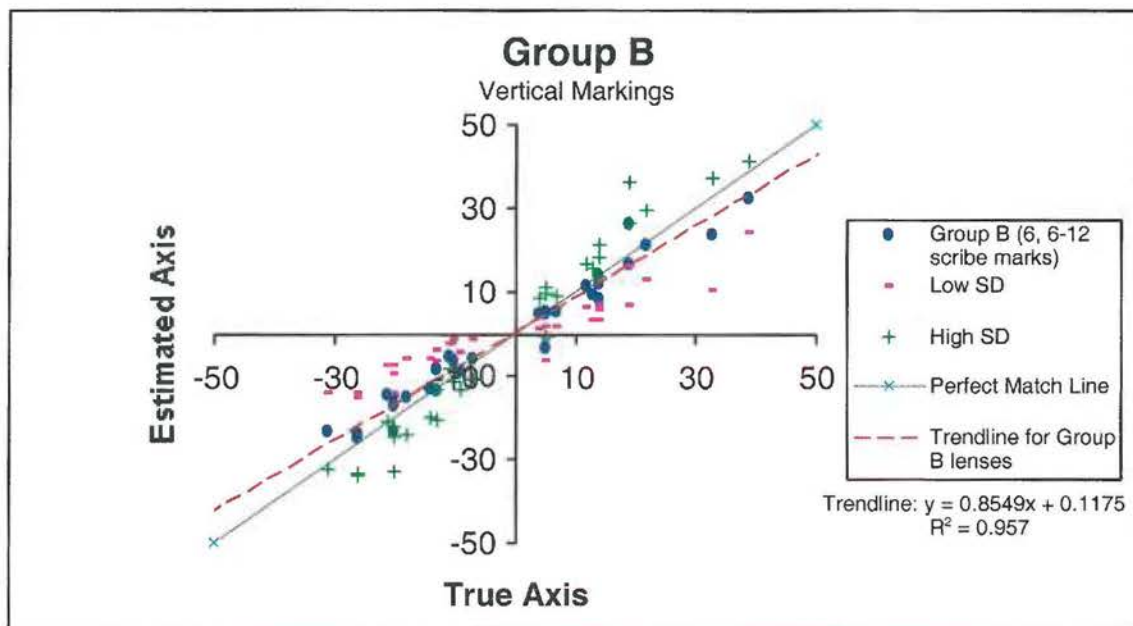


Figure 19. Plot of True vs. Estimated Axis for Group B Lenses

It can be seen in figures 18 and 19 that there is an increasing tendency to under estimate the rotation with increasing true rotation for the “B” lenses (slope .85), whereas the mean estimations for the “A” lenses remained quite close to true rotation (slope .95).

DISCUSSION

Our original intent was to see if there was a lens design that was judged more accurately than any others. We found that no single lens produced a more accurate estimation. However, we found that as a class the 3-9 (horizontal) scribe mark produced a more accurate estimation than the 6-12 (vertical) scribe mark. As far as gender is concerned there was no significant difference in making these judgments.

Without regard to types, there was a statistically significant difference between the true and observers' estimated angles. However, there was no particular difference among different types of lenses. Overall, observers underestimated the angles of rotation.

Without regard to types, there was no statistically significant difference between male and female's ability to estimate different angles of rotation i.e. there was no significant gender difference in making these judgments. However, there was a noticeable and statistically significant difference between male and female observers for the Vistakon 3-9 single and the Vistakon 6-12.

When groups of lenses which have horizontal (3 and 9) markings are compared to a group of lenses with vertical marks (at 6 or 6-12), there is a significant difference in angle estimation. Both Males and Females have less difficulty measuring an angle of rotation when observing horizontal scribe mark lenses. With vertically marked lenses there was a tendency for more estimation error as the true angle got larger. There was a tendency for the observers to make a lesser estimation error in the horizontal markings group than the vertical markings group. There is no significant difference between the estimated angle responses of females and males.

The implications of this data may be used by contact lens manufacturers. A lens that appears to rotate more than it really does could be seen by practitioners as being a bad lens. It really does not rotate more, but the perception could exist. For example, both a 3-9 lens and a 6-12 lens truly rotate 10 degrees. The practitioner overestimates the 3-9 lens compared to the 6-12 lens, so his/her perception is that the 3-9 lens is worse because it rotates "excessively."

Future studies should incorporate equal axis intervals for each lens tested in order to better analyze the effect of increasing the axis angle. Also, our experiment utilized 47 novice observers. It would be interesting to see if the results would change when testing the same number of experienced contact lens practitioners.

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Appendix A

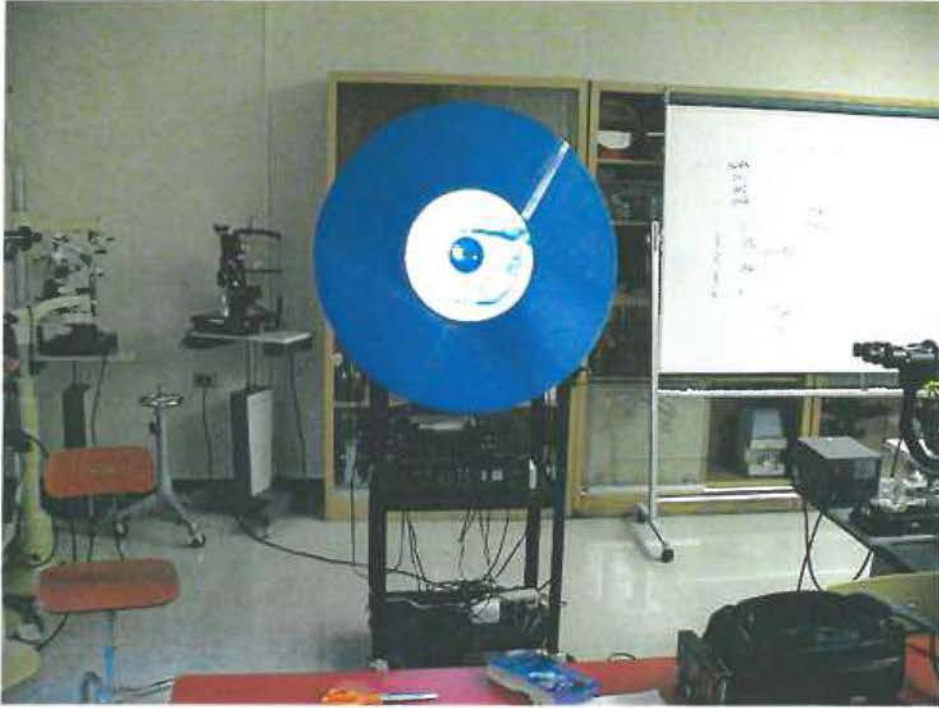


Figure A-1. Circular mat covering TV monitor.

For additional information see enclosed video tape and CD ROM