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THE EFFECT OF RADIAL EDGE LIFT VARIATION ON THE SPEED OF RGP LENS ADAPTATION

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Abstract

This project was designed to determine if the speed of adaptation to rigid gas permeable (RGP) lenses could be increased by initially fitting low edge lift lenses to reduce lid sensation, and subsequently switching the subject to the higher edge lift lens for long term wear. Thirty-two subjects were dispensed lenses and twenty-nine successfully wore the lenses for the entire eight week period. Half of the subjects wore a low edge design for four weeks, followed by a high edge design for the final four weeks. The remaining subjects wore identical pairs of high edge lift designs for both four week periods to serve as the control group. There were no significant differences in the speed of adaptation between the groups as measured by responses to a questionnaire completed by the subjects at each visit; however, large variations in staining and fitting performance for individual patients demonstrated the importance of customizing the peripheral curve system and the edge lift for each patient.

Key Words: **adaptation, axial edge lift, edge clearance, RGP, radial edge lift**

Introduction

Rigid gas permeable (RGP) lenses have several advantages over hydrogel lenses. RGP lenses allow for sharper vision than spherical hydrogels by masking corneal astigmatism. RGP lenses are also much easier to care for than hydrogel lenses. Cleaning and disinfecting methods are less expensive, less complicated, and less time consuming than those for hydrogels, and therefore better patient compliance is expected, along with fewer complications associated with protein deposits on the lens surface. Because of their typically higher oxygen permeability, hypoxic changes to the cornea associated with hydrogel and PMMA lenses can be minimized with RGPs. RGPs are also more durable and thus have a longer life than hydrogel lenses.

While RGP lenses have many advantages over hydrogel lenses, the main disadvantages are initial discomfort and awareness of the lens due to lid interaction with the lens.[1] The initial adaptation period for hydrogels is almost immediate, which is one reason many patients and practitioners opt for hydrogels over RGPs. However, with the many long term advantages favoring RGPs, a method to improve the initial comfort of RGPs and decrease the length of the adaptation period is needed.

Several studies suggest that low edge lift lenses are more comfortable than higher edge lift lenses due to decreased lid interaction.[2,3,4] Although low edge lift lenses theoretically ought to be more comfortable initially, there are complications associated with extremely low edges such as peripheral corneal desiccation and lens binding due to insufficient tear exchange under the low edge. The same complication of peripheral corneal desiccation can also occur if the edge lift is too high due to the tear meniscus receding underneath the lens edge and/or bubble formation at the lens edge.[3] It was formerly thought that by

decreasing the edge lift, peripheral corneal drying could be minimized.[2] However, Schnider and Andrasko have both reported that decreasing the edge lift tends to increase the amount of peripheral corneal desiccation.[5,6]

In order to interpret the literature on edge lift, edge clearance, and radial versus axial edge lift, a discussion of these terms as well as the function of the peripheral curve system of RGPs is needed. According to Musset and Stone, the purpose of the edge lift, which is created by the peripheral curve design, is to serve four functions: facilitating lens removal by allowing the lids to abut the lens; establishing adequate tear volume and circulation beneath the periphery of the lens to get oxygen and nutrients to the cornea and to clear debris from beneath the lens; aiding lens centration using the "capillary attraction" of the lens to the tear film; and preventing epithelial loss that would occur if the lens edge conformed to the cornea with associated lens movement.[3]

Despite the fact that edge lift and edge clearance are used interchangeably in the literature, the terms must be differentiated. To avoid confusion the investigators prefer the definitions given by Bibby. Edge lift refers to a measurement that is based on the extension of the base curve and is thus a "lens design specification", while edge clearance is the distance from the cornea to the edge of the lens and should be referred to as a "fitting specification".[7]

Edge lift values can be given in either of two forms: radial edge lift (REL) and axial edge lift (AEL). Radial edge lift is defined as "the extension of the lens edge perpendicular to the extension of the base curve,"[8] while "a measurement of the difference from the extension of the base curve up to the edge of the lens measured parallel to the axis of the lens" is defined as the axial edge lift of the lens. (Figure 1)

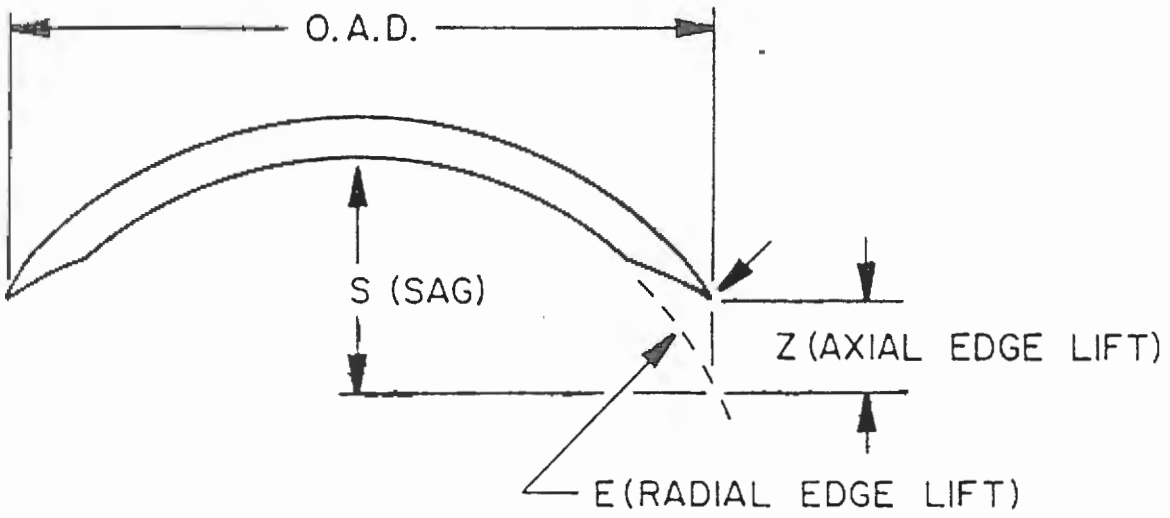

Figure 1: Pictorial representation of radial and axial edge lift. (From Bennett E.S.: Silicone/acrylate lens design. *Int. Contact Lens Clin.* 12(1):45-53, 1985. Reproduced by permission)[8]

Edge lift values cannot actually be measured, but are calculated from the base curve radius, and peripheral curve radii and widths. Because the AEL changes more than the REL if the diameter is kept constant over a range of base curves, REL is the preferred design specification.[7] For this reason, the investigators varied the REL in this study.

Stated edge lift values can be converted from axial to radial and vice versa using a formula that incorporates the base curve of the lens and the overall diameter of the lens:

$$e = \sqrt{r^2 + 2z} \quad \sqrt{r^2 - (d/2)^2} - r$$

$$z = \sqrt{(r + e)^2 - (d/2)^2} \quad - \sqrt{r^2 - (d/2)^2}$$

where e is the radial edge lift
z is the axial edge lift
r is the base curve radius
d is the overall diameter

This formula can be found in Contact Lens Design Tables, by Musset and Stone.[3]

The literature currently contains many references for suggested optimum edge lifts, most of which are reported in axial edge lift values (Table 1 and Figure 2). In a 1986 study by Bennett, the low AEL lens used was 0.115mm and the "conventional" AEL was 0.17mm[8]; Andrasko stated that 0.07mm is the low limit for the AEL, with normal AELs falling between 0.09mm and 0.12mm.[9] Musset and Stone suggested a 0.15mm AEL with a 9.00mm overall diameter(OAD) and also stated that the AEL should be no lower than 0.08mm.[3] Finally, Bibby suggested that the optimum REL is 0.093mm $\pm$ 0.015mm with a 0.100mm REL possibly becoming the "standard".[7] There appears to be a general consensus in the literature that normal edge lifts range from 0.09mm AEL to 0.12mm AEL for most diameters and base curve ranges (Figure 2).

Table 1 Table of recommended edge lifts by various authors with converted edge lift values in parentheses.*

		AEL	REL
Bennett	min.	.115	(.094)
	max.	.170	(.139)
Bibby	min.	(.092)	.078
	max.	(.127)	.108
Musset & Stone	min.	.080	(.066)
	max.	.150	(.123)
Towle, Huber, Coll	min.	(.071)	.060
	max.	(.142)	.120

*Authors typically suggest edge lift values in either AEL or REL only. For comparison, converted values were calculated by the authors with the formula listed by Musset and Stone, 1981. Table is based on arbitrary parameters of 7.50 mm base curve and 9.00 mm overall diameter.

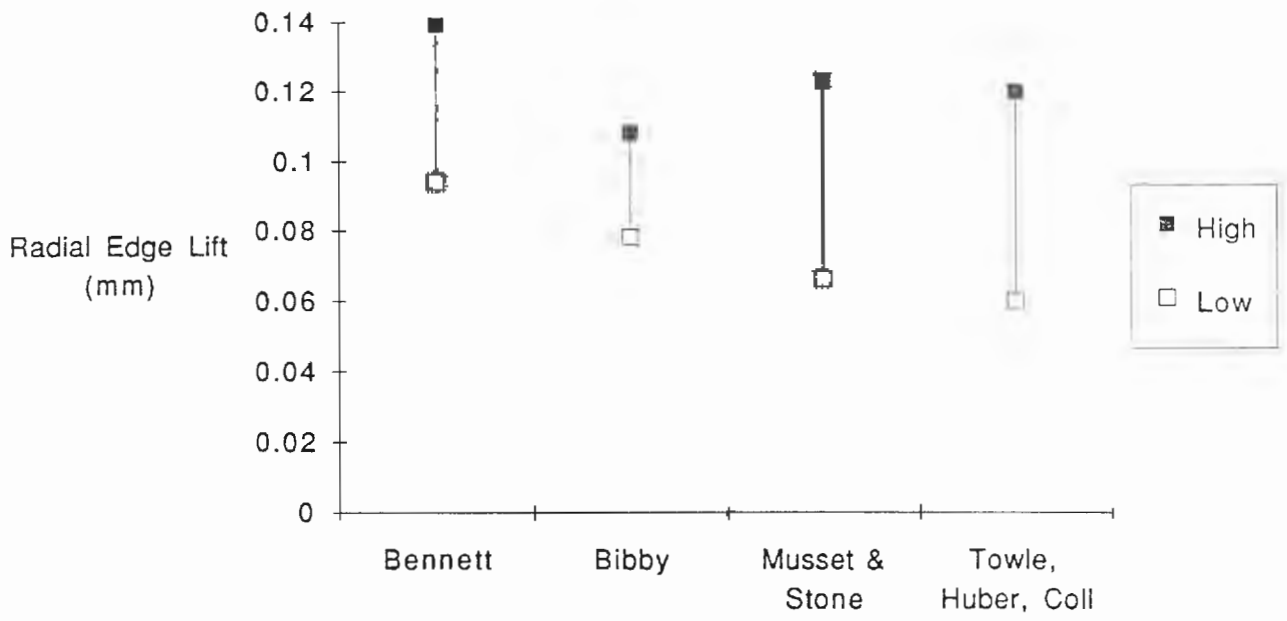

Figure 2 Recommended Edge lifts by Various Authors

Obviously there is a wide range in the literature of optimum moderate edge lifts as well as considerable variation on what constitutes a low and a high edge lift. For the purposes of this study, the investigators determined a normal range for REL to be from 0.08mm to 0.10mm. The investigators selected 0.06mm as the value for the low REL and 0.12mm as the value for the high REL since both fall outside the range the investigators defined as normal. It should be noted that based on lens parameters of 7.50mm base curve and a 9.00mm OAD, the defined optimum REL range of 0.08-0.10mm converts to 0.09-0.14mm AEL.

The investigators chose to study the effects of varying radial edge lift in RGP lenses to determine if a lower edge was more comfortable, thereby increasing the speed of adaptation, and to evaluate if a low edge lift design caused any undesirable side effects such as peripheral corneal desiccation. In addition, it was hypothesized that if low edge lift lenses did indeed increase the speed of adaptation, but also caused increased peripheral corneal desiccation, a two lens fitting system could be advantageous to the practitioner. A system for increasing the speed of adaptation to RGP lenses might consist of initially wearing a low edge lift lens to decrease discomfort and the length of the adaptation period, then switching to the higher edge lift lens to avoid increased corneal desiccation. A higher than average REL value was chosen deliberately to accentuate the difference between the low and high values.

Method

Subjects

Subjects were solicited via newspaper advertisements and screened for inclusion into the study. Subjects had to meet the following criteria: less than 2.00 diopters of corneal astigmatism, no recent history of rigid lens wear, and no history of dry eye, serious allergies, or corneal pathology. Successful hydrogel contact lens wearers were accepted. All subjects signed an informed consent document before undertaking lens wear. Subjects for whom acceptable fits were achieved were randomly placed into control and experimental groups.

The control group wore identical pairs of 0.12 mm REL lenses for each four week period, and consisted of 14 subjects. The experimental group wore 0.06 mm REL lenses for the first four weeks and 0.12 mm REL lenses for the second four week period, and contained 15 subjects. Details for each group

are listed in Table 2. A total of three subjects, one experimental and two from the control group, were unable to adapt to the lenses and withdrew from the study.

Table 2 Table of Subject Data

	N	Males	Females	Age range in years	Mean age in years
Control	14	6	8	15-44	26.1
Experimental	15	3	12	18-43	24.5
Totals	29	9	20	15-44	25.3

Lenses

Each subject underwent a trial fitting according to an alignment philosophy with both low (0.06 mm) and high (0.12 mm) REL pairs of Fluoroperm 60 lenses. Lens fits were deemed acceptable if the lenses displayed good centration, pupil coverage, and adequate movement in primary gaze. Base curve selection was undertaken to achieve fluorescein patterns showing apical alignment to minimal pooling across the flattest central corneal meridian. All trial fits were performed with 9.00 mm diameter lenses. When a larger lens was required to achieve an optimal fitting relationship, a 9.60 mm diameter with a 0.25 diopter flattening of the base curve was ordered to maintain the base curve to cornea fitting relationship. Peripheral curve radii and widths were ordered from specifications provided by Columbian Bifocal, Portland, OR (Appendix A).

Experimental procedure

Lenses were dispensed to twenty-nine subjects. Boston cleaner, Avant (Advance) conditioning solution, and Boston Advance reconditioning drops were supplied to each subject throughout the study. Proper cleaning, insertion, and removal techniques were assured prior to lens issue. At the dispensing visit, subjects were asked to wear the lenses each day as long as they were tolerable. Subjects were told they could use rewetting drops if needed. They were also asked to keep a daily log assessing comfort and hours of wear for the entire eight weeks of the study (Appendix B). Subjective comments regarding the lenses were encouraged.

Follow-up exams occurred at one week, two week, and four week intervals during each four week wearing period. Visual acuity, hours of wear for that day, and maximum daily wearing time for that pair of lenses were recorded. Spherical and spherocylindrical overrefractions were performed at each visit, and lens care regimen compliance was determined.

Objective data concerning lens fit and amount of fluorescein staining was collected. Corneal staining was rated as either clinically significant or clinically insignificant at each visit. Clinically significant staining was defined as "mild to dense coalescence" of punctate dots, while clinically insignificant staining included "isolated punctate staining" and absent or very minimal staining.[6]

Data analysis

All comfort reports were necessarily subjective, and patients were limited to five possible choices. Subjects were not asked to distinguish types of sensations or discomfort, but only told to rate their subjective response to the lenses. One subjective response score indicated the comfort response for both eyes.

Subjects were also asked to select their hours of wear for that day from a list of five possible wearing time ranges. For the purposes of this study, an increase in the daily wearing time was considered an increase in adaptation to the lenses. One score for the range of daily hours of wear indicated the wearing time for both eyes.

Subjective data compiled from the daily logs were evaluated using non-parametric statistics. The Mann-Whitney U-test was used to analyze the comfort and adaptation data between the experimental and control groups, and the Wilcoxon matched-pairs signed-ranks test was used to analyze the comfort and adaptation data within the low edge group, comparing the low edge lift lens data to the high edge lift data. Chi square statistics were used to analyze staining data.

Results

The mean comfort and adaptation findings reported by the subjects are shown in Figure 3 through Figure 6. Although there was an obvious improvement in comfort over the first four weeks of lens wear, there was no difference in comfort levels reported by the two groups. Similarly, the fifth through the eighth week data shows a plateau in comfort ratings but no significant difference was found between the two groups. Results for wearing time were more variable, and again, not significantly different for the two groups.

A significant difference was found in the amount of lens induced corneal staining between the two groups during both four week wearing periods, however. Using Chi square analysis on data from weeks 1-4, the experimental group, wearing low edge lift lenses, showed more staining than the high edge lift wearing control group ($p= 0.0064$). During weeks 5-8, the experimental

group, wearing high edge lift lenses, showed more staining than the high edge lift control group ($p= 0.0312$). Differences in the amount of corneal staining between groups is summarized in Figure 7.

Results observed, but not analyzed, were trends of increased superior lens decentration with the high edge lift lenses in both groups, and difficulty with lens removal with the low edge lift lenses.

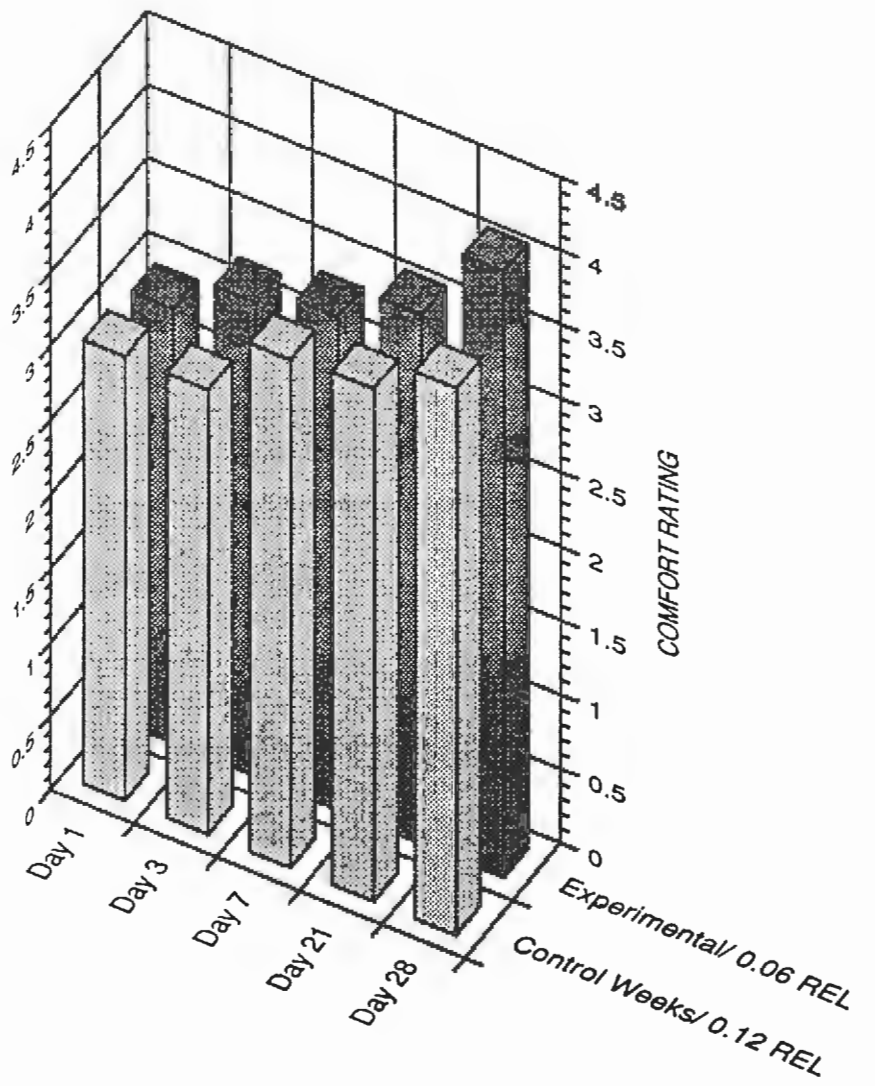

Figure 3: Mean comfort ratings for weeks 1-4

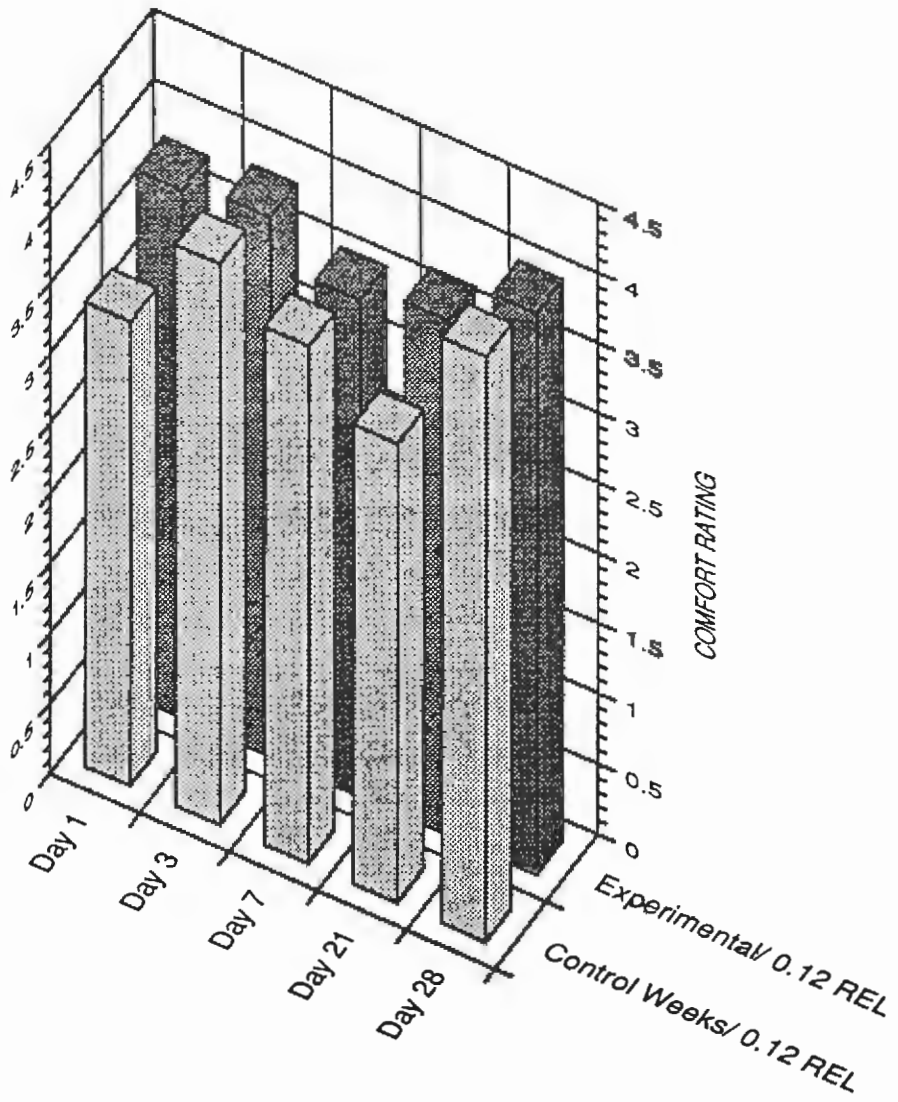

Figure 4 Mean comfort ratings for weeks 5-8

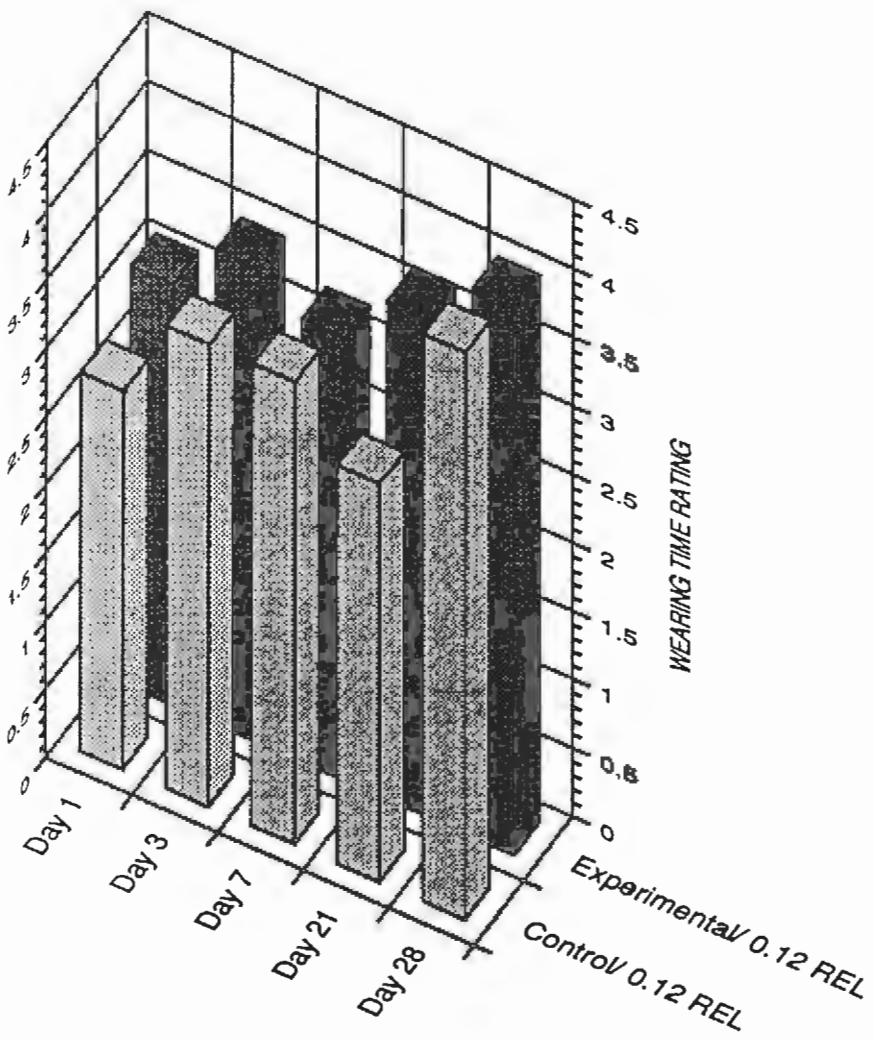

Figure 5: Mean wearing time ratings for weeks 1-4

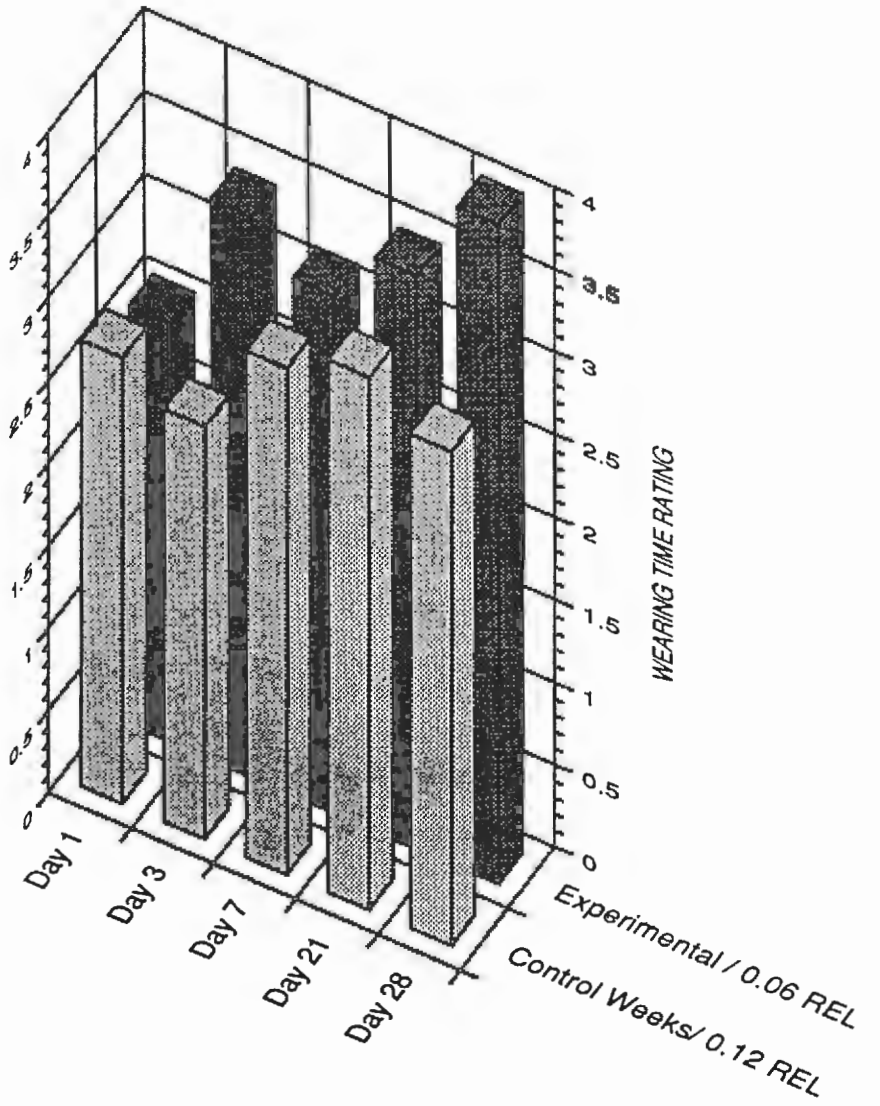

Figure 6: Mean wearing time ratings for weeks 5-8

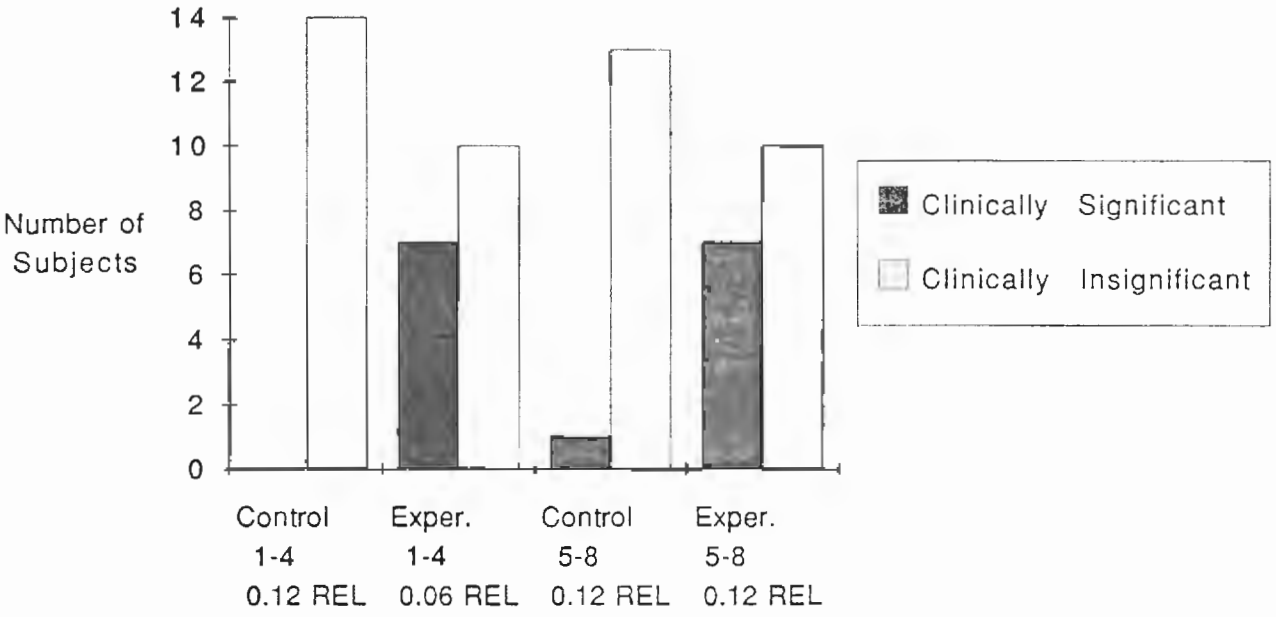

Figure 7: Incidence of corneal staining by weeks

Discussion

The hypothesis in this project was that the speed of adaptation to RGP lenses could be increased by initially fitting low edge lift lenses to reduce lid sensation, and subsequently switching the subject to the higher edge lift lens for long term wear without requiring re-adaptation. However, our results indicated that patients wearing high edge lift designs adapted just as well as those wearing low lift designs.

There are numerous possible reasons why the results of this study did not support the original hypothesis stated above. Assuming the study was properly designed and executed, the obvious possibility is that the hypothesis is incorrect, and RGP adaptation is independent of edge lift variation. It is our contention that the hypothesis remains true, but that REL can be varied over a broad range of acceptable edge lift values and not cause statistically significant changes in either comfort or speed of adaptation. The edge lift values chosen for this study may not have been extreme enough to fall outside the acceptable range of edge lift values and therefore were reported as equally comfortable. Alternatively, the values chosen may have been found equally uncomfortable by each group because they were too extreme and fell outside of the acceptable range.

If all of the high and low edge lift lenses used in this study were within such an acceptable range, there would be no measurable difference in comfort and adaptation between or within groups. This is supported by the finding that there were no comfort or adaptation differences between groups during the first four weeks of the study. A subject wearing both a low and a high edge lift lens is shown in Figure 8 and Figure 9. These photos demonstrate acceptable edge lifts for this patient and support the theory that the edge lifts chosen were not

extreme enough. However, on several other patients these same parameters gave either excessively high or excessively low edge clearance.

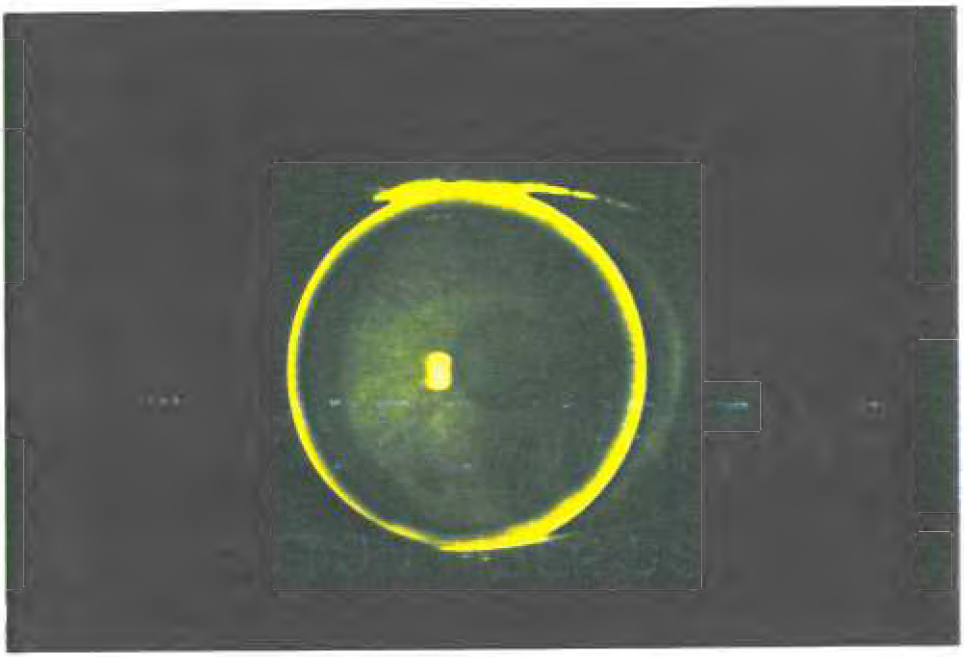

Figure 8: Photograph demonstrating a 0.06 REL lens with an acceptable edge pattern

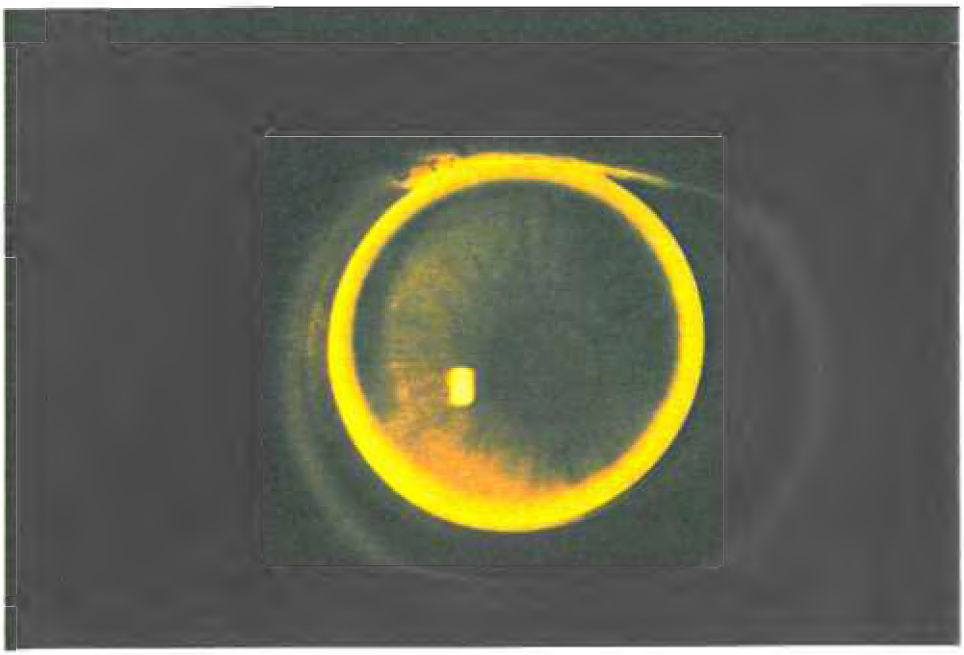

Figure 9: Photograph demonstrating a 0.12 REL lens with an acceptable edge pattern

Our belief is that the edge lift values chosen were too extreme in enough individual cases in both groups to yield no difference in comfort or adaptation between the groups. This is supported by the fact that the high edge lift lenses were positioned excessively high on many individuals in both groups with bubble formation underneath the edge being a notable finding. Several subjects in both groups also reported visual problems involving superior lens decentration with the high edge lift lenses. Conversely, a few of the low edge lift lenses provided insufficient tear volume underneath the lens and subjects reported removal difficulties with these lenses.

In an effort to simulate typical lens wear, subjects wore lenses with identical REL on each eye at the same time, but were then unable to simultaneously compare low edge clearance with high edge clearance as in studies where subjects wear low edge lift on one eye and high edge lift on the other. This may have been another factor contributing to the lack of significant comfort differences since direct comparison between the two edge clearances was impossible.

The subjects in the experimental group showed significantly more lens induced corneal staining when compared to the control group regardless of lens designs, but reported no corresponding differences in comfort or adaptation. Staining was greater with the low edge lift designs, however. We would not expect differences by chance in predilection for staining, as subjects were assigned to control and experimental groups randomly. Identical amounts of staining between groups were expected, but did not occur, when both groups were wearing the high edge lift lenses.

Since the experimental group did show greater staining for both low and high edge lift lenses, it is possible that low edge designs (which were worn first) cause longer term disruption of corneal cells than high edge designs. An

evaluation of whether or not low edge lift lenses have longer term detrimental staining effects on the cornea could be performed by having half of the subjects in the experimental group begin in low edge lift lenses and then switch to the higher edge; the other half would begin in the high and then switch to the low.

The combination of these findings indicate that individual variation in corneal topography makes it impossible to specify edge lift values which will always appear high or low. A better study design would be to trial fit with varying edge lifts to achieve visibly low versus normal or high edge clearances for each subject.

Obviously, based on the results of this study, the initial premise of a two lens fitting system to increase adaptation to RGP lenses is impractical and unnecessary. However, it is apparent in this study that low edge lift lenses yield increased peripheral corneal desiccation which may, in fact, affect the cornea long after the lens is removed. This confirms the optometric literature which states that both excessively high and excessively low edge clearances can yield varying degrees of peripheral corneal desiccation due to disruption of tear flow.

Due to variable rates of peripheral corneal flattening in subjects with identical central corneal keratometry readings, a knowledge of peripheral corneal topography is essential before a fixed relationship between corneal measurement and lens design can be established. In the meantime, trial fitting is essential to achieving an optimal fitting relationship. Although many practitioners are successfully fitting rigid gas permeable lenses, there is still a lot of guess work regarding how much to alter parameters if a patient develops problems such as peripheral corneal desiccation, lens binding, or inability to adapt to a lens. Even if the calculated REL is not available from a lab, knowing the radii and widths of the peripheral curves would allow a practitioner to flatten

the peripheral curve radii if the edge is too tight, steepen it if it is too high, widen it if it is too narrow, and so on. By knowing or specifying the parameters of the peripheral curve system in a trial set, a practitioner can help insure that the lens ordered will perform more like the trial lens.

Until more comprehensive and reliable methods of evaluating corneal shape are available, knowledge of the peripheral parameters of trial lenses and careful fluorescein evaluation during trial fitting will take some of the guess work out of RGP fitting and yield more successful RGP wear.

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APPENDIX A

Lens specifications with a 9.0 overall diameter and a 0.06 REL

Drop	**	Dia	IPC	/W	2IPC	/W	PC	/W	OC	Sag30	Sag60	Sag120	Sag240	Sag90	AEL	REL
.00	8.23	9.0	9.03	0.2	9.49	0.2	9.95	0.3	7.6	1.34	0.93	0.10	0.10	0.15	0.072	0.060
.25	8.18	9.0	8.98	0.2	9.42	0.2	9.85	0.3	7.6	1.35	0.94	0.10	0.10	0.15	0.072	0.060
.50	8.13	9.0	8.93	0.2	9.34	0.2	9.75	0.3	7.6	1.36	0.94	0.10	0.10	0.15	0.072	0.060
.75	8.08	9.0	8.88	0.2	9.28	0.2	9.67	0.3	7.6	1.37	0.95	0.10	0.10	0.15	0.072	0.060
.00	8.04	9.0	8.84	0.2	9.22	0.2	9.60	0.3	7.6	1.38	0.96	0.10	0.10	0.15	0.073	0.060
.25	7.99	9.0	8.79	0.2	9.14	0.2	9.50	0.3	7.6	1.39	0.96	0.10	0.10	0.15	0.072	0.060
.50	7.94	9.0	8.74	0.2	9.07	0.2	9.40	0.3	7.6	1.40	0.97	0.10	0.10	0.16	0.072	0.060
.75	7.89	9.0	8.69	0.2	9.02	0.2	9.35	0.3	7.6	1.41	0.97	0.10	0.10	0.16	0.073	0.060
.00	7.85	9.0	8.65	0.2	8.95	0.2	9.25	0.3	7.6	1.42	0.98	0.10	0.10	0.16	0.073	0.060
.25	7.80	9.0	8.60	0.2	8.89	0.2	9.17	0.3	7.6	1.43	0.99	0.10	0.10	0.16	0.073	0.060
.50	7.76	9.0	8.56	0.2	8.84	0.2	9.12	0.3	7.6	1.44	0.99	0.10	0.10	0.16	0.074	0.060
.75	7.71	9.0	8.51	0.2	8.77	0.2	9.02	0.3	7.6	1.45	1.00	0.10	0.11	0.17	0.074	0.060
.00	7.67	9.0	8.47	0.2	8.71	0.2	8.95	0.3	7.6	1.46	1.01	0.10	0.11	0.17	0.074	0.060
.25	7.63	9.0	8.43	0.2	8.65	0.2	8.87	0.3	7.6	1.47	1.01	0.10	0.11	0.17	0.074	0.060
.50	7.58	9.0	8.38	0.2	8.60	0.2	8.82	0.3	7.6	1.48	1.02	0.11	0.11	0.17	0.075	0.060
.75	7.54	9.0	8.34	0.2	8.53	0.2	8.72	0.3	7.6	1.49	1.03	0.11	0.11	0.17	0.074	0.060
.00	7.50	9.0	8.30	0.2	8.49	0.2	8.67	0.3	7.6	1.50	1.03	0.11	0.11	0.17	0.075	0.060
.25	7.46	9.0	8.26	0.2	8.43	0.2	8.60	0.3	7.6	1.51	1.04	0.11	0.11	0.18	0.075	0.060
.50	7.42	9.0	8.22	0.2	8.37	0.2	8.52	0.3	7.6	1.52	1.05	0.11	0.11	0.18	0.075	0.060
.75	7.38	9.0	8.18	0.2	8.32	0.2	8.47	0.3	7.6	1.53	1.05	0.11	0.11	0.18	0.075	0.060
.00	7.34	9.0	8.14	0.2	8.27	0.2	8.40	0.3	7.6	1.54	1.06	0.11	0.11	0.18	0.076	0.060
.25	7.30	9.0	8.10	0.2	8.21	0.2	8.32	0.3	7.6	1.55	1.07	0.11	0.12	0.18	0.076	0.060
.50	7.26	9.0	8.06	0.2	8.16	0.2	8.27	0.3	7.6	1.56	1.07	0.11	0.12	0.19	0.077	0.060
.75	7.22	9.0	8.02	0.2	8.11	0.2	8.20	0.3	7.6	1.57	1.08	0.11	0.12	0.19	0.077	0.060
.00	7.18	9.0	7.96	0.2	8.05	0.2	8.12	0.3	7.6	1.58	1.09	0.11	0.12	0.19	0.076	0.060

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Lens specifications with a 9.0 overall diameter and a 0.12 REL

Lop	MM	Dia	IPC	/W	CIPC	/W	PC	/W	CC	Sag°C	Sag°C	Sag°C	Sag°C	Sag°C	AEL	REL
41.00	8.23	9.0	9.23	0.2	11.62	0.2	14.00	0.3	7.6	1.34	0.93	0.09	0.08	0.10	0.142	0.120
41.25	8.18	9.0	9.18	0.2	11.49	0.2	13.80	0.3	7.6	1.35	0.94	0.09	0.08	0.10	0.143	0.120
41.50	8.13	9.0	9.13	0.2	11.38	0.2	13.63	0.3	7.6	1.36	0.94	0.09	0.08	0.10	0.143	0.120
41.75	8.08	9.0	9.08	0.2	11.27	0.2	13.46	0.3	7.6	1.37	0.95	0.10	0.08	0.10	0.144	0.120
42.00	8.04	9.0	9.04	0.2	11.16	0.2	13.29	0.3	7.6	1.38	0.96	0.10	0.08	0.10	0.144	0.120
42.25	7.99	9.0	8.99	0.2	11.05	0.2	13.12	0.3	7.6	1.39	0.96	0.10	0.08	0.11	0.145	0.120
42.50	7.94	9.0	8.94	0.2	10.95	0.2	12.95	0.3	7.6	1.40	0.97	0.10	0.08	0.11	0.145	0.120
42.75	7.89	9.0	8.89	0.2	10.84	0.2	12.78	0.3	7.6	1.41	0.97	0.10	0.08	0.11	0.145	0.120
43.00	7.85	9.0	8.85	0.2	10.73	0.2	12.61	0.3	7.6	1.42	0.98	0.10	0.08	0.11	0.146	0.120
43.25	7.80	9.0	8.80	0.2	10.62	0.2	12.44	0.3	7.6	1.43	0.99	0.10	0.08	0.11	0.146	0.120
43.50	7.76	9.0	8.76	0.2	10.52	0.2	12.29	0.3	7.6	1.44	0.99	0.10	0.08	0.11	0.146	0.120
43.75	7.71	9.0	8.71	0.2	10.43	0.2	12.14	0.3	7.6	1.45	1.00	0.10	0.09	0.12	0.147	0.120
44.00	7.67	9.0	8.67	0.2	10.33	0.2	11.99	0.3	7.6	1.46	1.01	0.10	0.09	0.12	0.147	0.120
44.25	7.63	9.0	8.63	0.2	10.23	0.2	11.84	0.3	7.6	1.47	1.01	0.10	0.09	0.12	0.148	0.120
44.50	7.58	9.0	8.58	0.2	10.14	0.2	11.69	0.3	7.6	1.48	1.02	0.10	0.09	0.12	0.148	0.120
44.75	7.54	9.0	8.54	0.2	10.05	0.2	11.56	0.3	7.6	1.49	1.03	0.10	0.09	0.12	0.148	0.120
45.00	7.50	9.0	8.50	0.2	9.97	0.2	11.43	0.3	7.6	1.50	1.03	0.10	0.09	0.12	0.149	0.120
45.25	7.46	9.0	8.46	0.2	9.88	0.2	11.30	0.3	7.6	1.51	1.04	0.10	0.09	0.13	0.150	0.120
45.50	7.42	9.0	8.42	0.2	9.79	0.2	11.17	0.3	7.6	1.52	1.05	0.10	0.09	0.13	0.150	0.120
45.75	7.38	9.0	8.38	0.2	9.71	0.2	11.04	0.3	7.6	1.53	1.05	0.11	0.09	0.13	0.150	0.120
46.00	7.34	9.0	8.34	0.2	9.62	0.2	10.91	0.3	7.6	1.54	1.06	0.11	0.09	0.13	0.151	0.120
46.25	7.30	9.0	8.30	0.2	9.54	0.2	10.78	0.3	7.6	1.55	1.07	0.11	0.10	0.13	0.151	0.120
46.50	7.26	9.0	8.26	0.2	9.47	0.2	10.68	0.3	7.6	1.56	1.07	0.11	0.10	0.13	0.152	0.120
46.75	7.22	9.0	8.23	0.2	9.40	0.2	10.58	0.3	7.6	1.57	1.08	0.11	0.10	0.14	0.153	0.120
47.00	7.18	9.0	8.18	0.2	9.32	0.2	10.45	0.3	7.6	1.58	1.09	0.11	0.10	0.14	0.153	0.120

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Lens specifications with a 9.6 overall diameter and a 0.06 REL

Diop	MM	Dia	IPC	/W	2IPC	/W	PC	/W	OZ	SagBC	SagOZ	Sag1IC	Sag2IC	SagPC	AEL	REL
.00	8.23	9.6	8.83	0.2	9.19	0.3	9.55	0.3	8.0	1.54	1.04	0.10	0.16	0.17	0.074	0.060
.25	8.18	9.6	8.78	0.2	9.12	0.3	9.45	0.3	8.0	1.56	1.04	0.11	0.16	0.17	0.073	0.060
.50	8.13	9.6	8.73	0.2	9.07	0.3	9.40	0.3	8.0	1.57	1.05	0.11	0.16	0.17	0.075	0.060
.75	8.08	9.6	8.68	0.2	8.99	0.3	9.30	0.3	8.0	1.58	1.06	0.11	0.17	0.17	0.074	0.060
.00	8.04	9.6	8.64	0.2	8.93	0.3	9.22	0.3	8.0	1.59	1.07	0.11	0.17	0.18	0.074	0.060
.25	7.99	9.6	8.59	0.2	8.87	0.3	9.15	0.3	8.0	1.60	1.07	0.11	0.17	0.18	0.075	0.060
.50	7.94	9.6	8.54	0.2	8.81	0.3	9.08	0.3	8.0	1.61	1.08	0.11	0.17	0.18	0.075	0.060
.75	7.89	9.6	8.49	0.2	8.75	0.3	9.01	0.3	8.0	1.62	1.09	0.11	0.17	0.18	0.076	0.060
.00	7.85	9.6	8.45	0.2	8.69	0.3	8.94	0.3	8.0	1.64	1.10	0.11	0.17	0.18	0.076	0.060
.25	7.80	9.6	8.40	0.2	8.64	0.3	8.87	0.3	8.0	1.65	1.10	0.11	0.17	0.18	0.076	0.060
.50	7.76	9.6	8.36	0.2	8.58	0.3	8.80	0.3	8.0	1.66	1.11	0.11	0.18	0.19	0.077	0.060
.75	7.71	9.6	8.31	0.2	8.52	0.3	8.73	0.3	8.0	1.68	1.12	0.11	0.18	0.19	0.077	0.060
.00	7.67	9.6	8.27	0.2	8.47	0.3	8.66	0.3	8.0	1.69	1.13	0.11	0.18	0.19	0.077	0.060
.25	7.63	9.6	8.23	0.2	8.41	0.3	8.59	0.3	8.0	1.70	1.13	0.11	0.18	0.19	0.077	0.060
.50	7.58	9.6	8.18	0.2	8.35	0.3	8.52	0.3	8.0	1.71	1.14	0.12	0.18	0.20	0.077	0.060
.75	7.54	9.6	8.14	0.2	8.30	0.3	8.45	0.3	8.0	1.72	1.15	0.12	0.18	0.20	0.077	0.060
.00	7.50	9.6	8.10	0.2	8.24	0.3	8.38	0.3	8.0	1.74	1.16	0.12	0.19	0.20	0.077	0.060
.25	7.46	9.6	8.06	0.2	8.19	0.3	8.33	0.3	8.0	1.75	1.16	0.12	0.19	0.20	0.078	0.060
.50	7.42	9.6	8.02	0.2	8.14	0.3	8.26	0.3	8.0	1.76	1.17	0.12	0.19	0.20	0.078	0.060
.75	7.38	9.6	7.98	0.2	8.08	0.3	8.19	0.3	8.0	1.78	1.18	0.12	0.19	0.21	0.078	0.060
.00	7.34	9.6	7.94	0.2	8.04	0.3	8.14	0.3	8.0	1.79	1.19	0.12	0.19	0.21	0.079	0.060
.25	7.30	9.6	7.90	0.2	7.98	0.3	8.07	0.3	8.0	1.80	1.19	0.12	0.20	0.21	0.079	0.060
.50	7.26	9.6	7.86	0.2	7.94	0.3	8.02	0.3	8.0	1.81	1.20	0.12	0.20	0.21	0.080	0.060
.75	7.22	9.6	7.82	0.2	7.89	0.3	7.97	0.3	8.0	1.83	1.21	0.12	0.20	0.22	0.080	0.060
.00	7.18	9.6	7.78	0.2	7.84	0.3	7.90	0.3	8.0	1.84	1.22	0.12	0.20	0.22	0.080	0.060

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Lens specifications with a 9.6 overall diameter and a 0.12 REL

Drop	MM	Dia	IPC	/W	2IPC	/W	PC	/W	CT	SagBC	SagOZ	Sag1IC	Sag2IC	SagPC	AEL	REL
1.00	8.23	9.6	9.03	0.2	10.64	0.3	12.25	0.3	8.0	1.54	1.04	0.10	0.13	0.12	0.148	0.120
1.25	8.18	9.6	8.98	0.2	10.53	0.3	12.08	0.3	8.0	1.56	1.04	0.10	0.14	0.13	0.148	0.120
1.50	8.13	9.6	8.93	0.2	10.42	0.3	11.91	0.3	8.0	1.57	1.05	0.10	0.14	0.13	0.148	0.120
1.75	8.08	9.6	8.88	0.2	10.34	0.3	11.80	0.3	8.0	1.58	1.06	0.10	0.14	0.13	0.149	0.120
2.00	8.04	9.6	8.84	0.2	10.25	0.3	11.67	0.3	8.0	1.59	1.07	0.10	0.14	0.13	0.149	0.120
2.25	7.99	9.6	8.79	0.2	10.16	0.3	11.54	0.3	8.0	1.60	1.07	0.11	0.14	0.13	0.150	0.120
2.50	7.94	9.6	8.74	0.2	10.08	0.3	11.41	0.3	8.0	1.61	1.08	0.11	0.14	0.13	0.150	0.120
2.75	7.89	9.6	8.69	0.2	9.99	0.3	11.28	0.3	8.0	1.62	1.09	0.11	0.15	0.14	0.151	0.120
3.00	7.85	9.6	8.65	0.2	9.90	0.3	11.15	0.3	8.0	1.64	1.10	0.11	0.15	0.14	0.151	0.120
3.25	7.80	9.6	8.60	0.2	9.81	0.3	11.02	0.3	8.0	1.65	1.10	0.11	0.15	0.14	0.151	0.120
3.50	7.76	9.6	8.56	0.2	9.72	0.3	10.89	0.3	8.0	1.66	1.11	0.11	0.15	0.14	0.152	0.120
3.75	7.71	9.6	8.51	0.2	9.66	0.3	10.80	0.3	8.0	1.68	1.12	0.11	0.15	0.14	0.153	0.120
4.00	7.67	9.6	8.47	0.2	9.59	0.3	10.70	0.3	8.0	1.69	1.13	0.11	0.15	0.14	0.154	0.120
4.25	7.63	9.6	8.43	0.2	9.50	0.3	10.57	0.3	8.0	1.70	1.13	0.11	0.15	0.15	0.154	0.120
4.50	7.58	9.6	8.38	0.2	9.42	0.3	10.47	0.3	8.0	1.71	1.14	0.11	0.16	0.15	0.155	0.120
4.75	7.54	9.6	8.34	0.2	9.35	0.3	10.35	0.3	8.0	1.72	1.15	0.11	0.16	0.15	0.155	0.120
5.00	7.50	9.6	8.30	0.2	9.28	0.3	10.25	0.3	8.0	1.74	1.16	0.11	0.16	0.15	0.156	0.120
5.25	7.46	9.6	8.26	0.2	9.20	0.3	10.15	0.3	8.0	1.75	1.16	0.11	0.16	0.15	0.157	0.120
5.50	7.42	9.6	8.22	0.2	9.12	0.3	10.02	0.3	8.0	1.76	1.17	0.12	0.16	0.16	0.156	0.120
5.75	7.38	9.6	8.18	0.2	9.05	0.3	9.92	0.3	8.0	1.78	1.18	0.12	0.16	0.16	0.157	0.120
6.00	7.34	9.6	8.14	0.2	8.98	0.3	9.82	0.3	8.0	1.79	1.19	0.12	0.17	0.16	0.158	0.120
6.25	7.30	9.6	8.10	0.2	8.91	0.3	9.72	0.3	8.0	1.80	1.19	0.12	0.17	0.16	0.158	0.120
6.50	7.26	9.6	8.06	0.2	8.84	0.3	9.62	0.3	8.0	1.81	1.20	0.12	0.17	0.17	0.159	0.120
6.75	7.22	9.6	8.02	0.2	8.77	0.3	9.52	0.3	8.0	1.83	1.21	0.12	0.17	0.17	0.159	0.120
7.00	7.18	9.6	7.98	0.2	8.72	0.3	9.45	0.3	8.0	1.84	1.22	0.12	0.17	0.17	0.161	0.120

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APPENDIX B

Appendix B Sample daily questionnaire

How comfortable were the lenses today?

1 Intolerable - could not wear
2 Poor - very uncomfortable
3 Fair - wore despite discomfort
4 Good - noticed lenses, no problems
5 Excellent - minimal lens awareness

How many hours did you wear your lenses today?

1 0 - 2
2 3 - 5
3 6 - 8
4 9 - 11
5 12 or more

How did today's wearing compare to yesterday's?

1 much worse
2 worse
3 same
4 better
5 much better

How many times did you use comfort drops today?

1 4 or more times
2 3 times
3 2 times
4 1 time
5 0 times

Comments:

_____

_____

_____