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Refitting long term PMMA wearers: A preliminary study of corneal rehabilitation with gas permeable RX-56 lenses

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Abstract

Corneal exhaustive syndrome is a term which has been used to describe a number of long term PMMA contact lense wearers who either drop out of contacts or require some sort of refitting to remain in contact lenses. Four patients were refit with RX-56 lenses with a specific fitting philosophy of apical clearance and the physiological responses were monitored. Preliminary findings indicate initial corneal flattening with a corresponding decrease in spectacle minus refractive power, followed by corneal steepening and an increase in spectacle minus power. Corneal thinning occurred across the entire horizontal corneal meridian, and in two cases with mild keratometer mire distortion, distortion was eliminated. For the three patients that had pre-wear contact lense data available, there was not a return to the original base line prefit parameters. But the findings did show changes which suggest the same pattern of change as would be found with lens withdrawal or reduced wearing time. Additional study with larger samples and control groups are needed.

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REFITTING LONG TERM PMMA WEARERS:
A PRELIMINARY STUDY OF CORNEAL REHABILITATION
WITH GAS PERMEABLE RX-56 LENSES

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Contact Lenses

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A
Midterm Grade

A
Final Grade

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PREFACE

This project represents a preliminary study of the effectiveness of refitting long term PMMA contact lense wearers with gas permeable hard lenses. It was also used to identify future aspects of corneal rehabilitation that need to be studied in closer detail.

ABSTRACT

Corneal exhaustive syndrome is a term which has been used to describe a number of long term PMMA contact lense wearers who either drop out of contacts or require some sort of refitting to remain in contact lenses. Four patients were refit with RX-56 lenses with a specific fitting philosophy of apical clearance and the physiological responses were monitored. Preliminary findings indicate initial corneal flattening with a corresponding decrease in spectacle minus refractive power, followed by corneal steepening and an increase in spectacle minus power. Corneal thinning occurred across the entire horizontal corneal meridian, and in two cases with mild keratometer mire distortion, distortion was eliminated. For the three patients that had pre-wear contact lense data available, there was not a return to the original base line prefit parameters. But the findings did show changes which suggest the same pattern of change as would be found with lens withdrawal or reduced wearing time. Additional study with larger samples and control groups are needed.

INTRODUCTION

Recent literature indicates that there are a large number of long term hard PMMA contact lense wearers who eventually present themselves for Optometric care. Increase lense sensation and discomfort, reduced wearing time, lengthy spectacle blur and more seriously, reduced visual acuity with the best spectacle correction in place[1-7,10,11], describe a group of symptoms that will be referred to as "Corneal Exhaustive Syndrome".

A number of articles suggest ways to clinically manage these patients but there is a lack of clear consensus on the best method in refitting them[1-9]. This variety of opinions appears to stem in part from the various authors' belief as to the etiology of the problem, e.g. poor fit, hypoxia and physiological changes, mechanical deformation of the cornea, or the individual patient response to contact lense wear.

Management of these patients commonly include: 1) Complete lens withdrawal until corneal stabilization[6,8] 2) Reduced wearing time followed by the withdrawal or refit[3,6] 3) Immediate refit with hydrogel lenses[13,22] 4) Immediate refit with hard PMMA or gas permeable contact lenses[4,6,7].

Older literature suggested complete withdrawal until corneal stabilization has occurred as one therapy of choice[9,11,12,14,20]. Recent literature contraindicates complete withdrawal unless severe pathology is present[4,6,7,21], i.e. complete withdrawal usually results in greater induced corneal astigmatism. This older method of therapy

results in the most rapid corneal stabilization compared to reduced wearing time and hydrogel refitting methods[13]. Large refractive changes makes it difficult to maintain good visual acuity with spectacle correction by this method[8].

The second method, reduced wearing time, will often allow significant corneal intergrity improvement but requires a longer period of time for stabilization to occur before refitting[13]. The visual acuity during non contact lense wear may be compromised[21].

The third method, refitting with hydrogel lenses, usually will not mask corneal astigmatism, will require multiple changes to maintain best visual acuity during the period of unstable refraction[22], and apparently will take the longest period of time of the aforementioned methods[12,13].

Current literature advocates the use of the fourth method, immediate refitting[4,6,7,21]. In the absence of severe pathology, immediate refitting affords the patient with continued good visual acuity and a return to a healthy corneal integrity. This helps maintain patient motivation and patient satisfaction with the pracitioner's care.

Many articles imply the problems are due to an ill-fitting lens, however, even with the best fit PMMA lens, it has been shown that problems may occur[15,16].

Many studies have shown the problems are due to the hypoxia of the cornea, therefore, gas permeable hard contact lenses have been advocated to resolve this difficulty. It must be remembered that gas permeability is not enough by itself, a well fitted lens is also necessary to supply the maximum attainable oxygen to the cornea[17].

However, in these articles, how best to refit the patient is quite variable. For instance, many articles inadequately define what the physical fit of the lens actually is[1,2,4,5,6,10,11].

Other articles suggest simply duplicating the lens currently worn in a gas permeable material[4,5].

Certain practitioners have suggested somewhat arbitary modifications to various parameters of the old PMMA lenses using gas permeable materials, with reported success[1,4,6,18].

Other authors use pre-contact wear data in some way to modify the new lense parameters[1,22].

Many practitioners use a direct order method by which they order the base curve from the keratometer reading. It has been shown that in compromised corneas, the keratometer findings are unrealiable and have wide flucatuations and an optimum cornea-lens relationship may not be attained with this method[8]. Also, it is a common misconception that "on K" represents a cornea-lens fitting relationship of alignment, "steeper than K" represents apical clearance, and "flatter than K" represents apical touch. However, keratometric finding do not predict córneal-lens relationships unless the sagittal depth of the contact lens and the cornea happened to match[19].

Still others recommend diagnostic lense fitting using slight apical clearance with an adequate peripheral tear reservior. No clear cut quanitative method has been given for determining apical clearance or adequate tear reservior[8].

From the above, it is obvious that there is a wide variety of refitting philosophies, most with reported success. There is little basic research indicating the best method of corneal rehabitation. Therefore, the purpose of this pilot study is to begin to collect basic data to compare different refitting philosophies and gas permeable hard contact lense materials. The original intention was to work with patients with the aforementioned corneal exhaustive syndrome. Only four long term PMMA lense wearers with mild symptoms and marginal fits

met the criteria for subject selection. These were refitted with a specific refitting philosophy utilizing RX-56 CAB gas permeable lenses and monitored for changes in their physical parameter.

METHODS

SUBJECTS-Subjects were solicited from the Optometry student body and from the clinical population at Pacific University College of Optometry in the Forest Grove Clinic. Long term PMMA wearers were sought with one or more of the following general symptoms: 1) reduced comfort or wearing time, 2) reduced acuity through current spectacle correction compared to contact lens acuities, 3) reduced acuity through best spectacle correction, 4) contact lens dependence due to the above loss of acuity, 5) keratometer mire distortion upon removal of contact lenses, and 6) the patients had to be currently wearing hard contact lenses and desires to continue wearing contact lenses. Subjects were screened for the above mentioned objective signs and/or symptoms. Only those subjects without pathology and capable of being fit with spherical base curve lenses were entered into the study. Two male and two female optometry students were selected for the study. Age ranged from twenty-one to thirty-three years, PMMA wearing time ranged in length from seven years to twenty years and the equivalent sphere ranged from a low of -.50 diopters to a high of -6.37 diopters. None of the patients had severe corneal exhaustive problems. Major symptoms were spectacle blur and reduced comfort. Two patients showed mild keratometer distortion.

MATERIALS-RX-56 CAB lenses were ultilized for refitting, standard parameters as made by the manufacturer were used. (Appendix 1)

APPARATUS-The following diagnostic equipment was used:

1) The exam room was not held constant. The refracting distance

was a constant at 18 feet in length,

2) Either a B & L Greens or an A.O. Ultramatic phoropter,

3) International Diagnostic Instruments (IDI), corneascope and comparator,

4) Diagnostic Concepts (Dicon) electronic digital pachometer, model number C 6090, used for pachometry measurements,

5) Marco Slit Lamp Model 253 with 1.6 eyepieces and 1.0 or 1.6 objectives,

6) Diagnostic RX-56 lens set, and

7) Standard clinical flourescein strips.

PROCEDURES-Patients were initially screened for inclusion into the study. Pre-refitting data was collected in the following areas: 1) Current contact lens over-refraction, 2) slit lamp evaluation, 3) post-refraction, 4) post Ks, 5) pachometry, 6) post corneascope pictures, 7) current contact lens parameters, and 8) wearing history. Where available, original prefit data was collected. Diagnostic RX-56 lenses were used to evaluate the best cornea-lens relationship for refit. Lenses were then ordered. The lenses were verified upon arrival and dispensed if accepted. Physical parameters measured originally were then monitored again in periods ranging from one to three months. Slight modifications included, light blending, flattening of the peripheral curves, edge modification, and minor power modifications to balance the over-refraction.

With regards to the pachometry, calibration was performed on known thickness PMMA lenses according to the manufacturer's suggested procedures and therefore data collected is a relative measure of corneal thickness. Measurements were taken at the nine available fixation points across the entire horizontal meridian according to the manufacturer's procedures. Three readings were averaged and recorded if their standard deviation was less than 0.0092.

The corneascope with its comparator was used according to the manufacturer's suggested useage.

In evaluating the current fit, diagnostic fit, and refit, a special technique was ultilized. This technique will be referred to as the lacrimal line-reference line ratio (LL/RL). The slit lamp set up has the thinnest cobalt blue optical section with the illumination system perpendicular to the central cornea and the microscope was located approximately fifty-five degrees temporally ultilizing the highest magnification (25.6X) and with maximum voltage to the illumination system. The reference line (RL) is the thin tear layer on the anterior contact lens surface and the lacrimal line (LL) is the tear layer between the contact lens and the cornea.

With flourescein, the LL and RL will be seen as two thin green lines with the dark space in between representing the contact lens. The RL is assumed to be the approximate thickness of the pre-corneal tear film. If the contact lense base curve is adjusted so that the LL has the same thickness as the RL, this is assumed to be an approximate alignment fit representing a 1.0 ratio. If the LL is thicker than the RL, this is assumed to represent an apical clearance or a greater than a 1.0 ratio, and if the LL is thinner than the RL, this is assumed to represent an apical touch situation or a ratio of less than 1.0.

Using this method allows the pracititioner to visualize the fitting relationship in the entire vertical meridian. With experience, it becomes easy to detect bearing zones where the lacrimal line is thinner than the reference line or has a ratio of less than 1.0. In areas where the LL is thinner than the RL, care must be taken not to include the corneal epithelial optic section line as part of the

lacrimal line. The epithelial optic section is bluish and it is important to not confuse this with the green LL.

This method can also be used to evaluate how smoothly the blend occurs between the optic zone and the peripheral tear reservior. The shape of the tear reservior can be observed and peripheral curve alignment, touch, or clearance can be estimated. This peripheral curve region at the base of the contact lens should form a triangular shaped LL, referred to as the tear triangle, with the apex pointing up. Ideally the apex should not come to a point, but instead thin and then blend smoothly into the optic zone LL region superiorly. Inferiorly, the base of the triangle should be thicker than the RL by an amount that allows the tear meniscus to form at the edge of the contact lens rather than be pushed out from under the lens. If the peripheral curve is too flat, the tear meniscus is drawn up under the lens and this is easily seen with the LL/RL slit lamp set up.

The fitting philosophy that was attempted included: 1) Apical clearance, with the LL/RL ratio greater than 1.0 but less than 1.6, 2) smooth transition from the optic zone to the peripheral tear reservior, and 3) placing the peripheral tear mensicus at the edge of the contact lense, the tear reservoir was made to be approximately thirty percent of the contact lens area.

RESULTS

Due to the small number of patients, statistical analysis is inappropriate for this study. There was patient variability in the response to being refit with the gas permeable lenses.

Using keratometer findings, three of the four patients showed either some corneal flattening or no change by the end of the data collection period while one patient showed corneal steepening. Of the subjects who showed initial flattening, one later showed a gradual steepening with an apparent stabilization while for the other two patients, there was insufficient data due to the short period of the study to identify a resteepening trend. These patterns were evident using both the keratometer and corneascope findings.

Of the four patients, seven eyes showed an initial decrease in myopia. One eye demonstrated a gradual increase in myopia. In two of the patients, after the initial decrease in myopia, a gradual increase in myopia occurred. In the other two patients, only the decrease in myopia has been noted. Corneal curvature as measured by the keratometer were correlated with the change in refraction. Usually the changes were in similar directions however there was little one to one correspondence. Occassionally, there was a refractive change with no corresponding change in corneal curvature and rarely the refractive change was in the opposite direction to the change in the apparent corneal curvature.

With regards to astigmatism, the spectacle cylinder in two patients fluctuated in amount and axis without significant change.

The other two patients showed an unequal and variable pattern. One patient had one eye decrease in spectacle cylinder while the other eye increased slightly. The other patient had one eye decrease in cylinder while the other eye ended relatively unchanged from the pre-refit data. In both of these last two patients, the cylinder amount fluctuated up and down and the axis was also unstable. Apparent stability was not observed by the end of the study period.

Keratometric cylinder values showed that in three of the patients (six eyes) plus one eye of the fourth patient, there was an increase in keratometer cylinder values followed by apparent stabilization of the amount in four eyes. The other four eyes showed an initial increase followed by decrease. Three of these last four eyes showed an increase at this point while the last one was the only one to decrease to the base line value taken at the time of refitting. All seven of the other eyes ended with keratometric cylinder values greater than those found at refitting.

In comparing the corneascope values with the keratometer findings, some caution is necessary because the corneascope keratographs were evaluated in the 90th and 180th meridians and therefore can not be directly compared to the keratometer findings in most cases. In general the corneascope values are flatter than the keratometer values. The amount of corneal toricity is unpredictable in relation to the amount found by the keratometer, sometimes being less and sometimes more. No obvious pattern is discernable.

Concerning astigmatic axis, there was wide fluctuation of the spectacle cylinder axis as well as the keratometric axis. It was the exception rather than the rule for the spectacle axis to correspond with the keratometric axis.

The central cornea showed pachometric thinning in all patients. Most patients showed thinning across the entire horizontal meridian. Some showed fluctuations both increasing and decreasing which probably represent a stable thickness with random error of measurement combined with diurnal corneal thickness variations.

In the two patients that showed mild keratometric mire distortions, the distortions were eliminated in the course of this study.

DISCUSSION

As can be seen by refitting these patients with an apical clearance philosophy combined with gas permeable hard RX-56 lenses, a number of physical parameter changes were noted. Because of the small number of patients and the short period of observation, it is hazardous to make generalizations from this study.

Due to the large number of variables such as flat fit of the previous lens, steep fit of the previous lens, the amount of lens rocking, the degree of corneal hypoxia, the number of years of wear, and others, one would not expect to see a single pattern of change. What is encouraging is that the changes seem to be toward a better physiological health condition based on the finding of a generalized corneal thinning, a reduction of keratometer mire distortion when present, and a trend toward a lesser degree of corneal fluctuations.

Since this study is a preliminary study for future research, many variables were evaluated to try to get an overall picture on this complicated problem. From this study, some areas have been identified as needing further research.

Pachometry was a minor problem in itself. Initially the instrument's printout mechanism proved faulty as did calibration of the memory for eliminating the standard operator error. These were resolved early and there is some certainty that the data that was collected is reliable. Future studies using this instrument should make some attempt to maintain a fixed lateral head position of the patient in the instrument when performing pachometry.

Head position could change slightly from one time to the next causing the corneal position as measured to vary one time to the next. Head position was not controlled in this study. Also, all patients showed corneal thinning between the initial evaluation in November, 1981, and the dispensing of the RX-56 lenses after January, 1982. The source of this general thinning is unclear. Operator or an instrument error could be the source.

The use of the corneascope in corneal rehabitation needs to be investigated more thoroughly. Does the corneascope provide an accurate measurement for the refitting of problem corneas? In this study, the lens predicted by the corneascope in each case did not resemble the diagnostic lens selected as best fit. Typically the optic zone diameter suggested was smaller than the standard RX-56 optic zone diameter. Taking into account the change in base curve due to the optic zone differnces using the Harris-Kubo ratio (using PUCO's constant of .12), we found that the corneascope still suggested a flatter base curve than that which was selected by the diagnostic lense fit.

A number of problems were encountered with Rynco's RX-56 lenses. Over half of the PUCO fitting set had base curve warpage greater than 0.25 diopters and many in the 0.50 diopter range. This made trial fitting quite complicated for both the base curve and power determination. More than fifty percent of the received lenses were rejected because of flat or warped (greater than 0.25 diopters) base curves. Experience proved that the base curve received was almost invariably 0.05mm flatter than that ordered and sometimes as mush as 0.10mm flatter. Warpage in the received lenses varied up to 0.75 diopters. Base curves were verified both on a radius scope and on a keratometer.

Although the actual radius of curvature varied between the two instruments slightly, the relative results were approximately the same. Further study of the stability of these lenses is needed. The lenses were hydrated by the manufacturer prior to shipment but most were dehydrated by the time they were received. The lenses were rehydrated twenty four or more hours before verification was performed. The effect on lense parameters due to dehydration and rehydration should be studied. In personal communication with the Rynco laboratory, their manufacturing tolerance was stated to be plus or minus 0.05mm for the base curve delivered to the practicioner. However, the lenses that were received were often outside this range and most often flatter. Also this level of tolerance is well outside that stated for hard lens materials in standard contact lens textbooks of $\pm$0.02mm[23].

When the lenses were first dispensed, wetting was often a problem even with several lense cleanings and the use of the recommended solutions of the Flex Care group or the Softmate group. It was found after the first day of wear, wetting improved. Also, it was found that the use of Allergan's "Liquifilm" for wetting, Burton, Parsons, & Company's "Soacleans" for soaking, and Lobob Laboratories' "Lobob" for cleaning was the best care regime for the patients.

Two of the patients complained of visual discomfort that was vague in nature. One of these patients had an unusual buildup of deposits on minor scratches of the lens affecting visual acuity after several hours of wear and required frequent cleaning. Because the base curve ordered was not reliably reproduced as sent from the manufacturer, binocular balancing required lens modfications of power in three of the four patients. It may be a coincidence, but both of the patients with visual complaints were fit with a clinically warped

RX-56 lenses in one eye. The amount of warpage of one patient was one quarter of a diopter and of the other patient, one half of a diopter.

Using the lacrimal line, reference line to evaluate the contact lense fit needs further study. Although both investigators had similar backgrounds in understanding this system, used the same instrument set up, had a similar experience level using this method of evaluation, it was found that there was a consistant difference between the investigators on the same patient in judging the LL/RL, i.e., one investigator's estimate was always higher by approximately 0.4. Therefore only one investigator judged the LL/RL ratio to reduce experimental variability. Because of this, it is suggested that further study of this fitting system is needed. Earlier investigators using older model slit lamps felt this to be an unreliable method for evaluating a contact lense fit[24]. Experimentation as to how to consistently produce the best optic section is needed because it was found that the LL/RL ratio estimate changed with varying the optic section width. Increased magnification was helpful in estimating and optimum magnification giving the least variability should be sought. With this information, double blind studies should be performed to determine the ability of a single observer to judge different lense fits and different observers to judge the same lens fit.

To provide the best clinical data possible and to deal with the refitting of long term PMMA wearers, a longer period of observation is needed. In order for this to occur, a continuing study is recommended where by an established protocol is in place and the study is passed on in such a way that the pitfalls of previous experience do not have to be repeated. With the overseeing guidance of their advisor, one year's

group of interns could train the next year's group of interns to continue and improve the areas being studied thus providing continuity to the study, patient care, and data collection.

It is recommended that a "contact lense clinic" concept be strengthened so that all contact lens patients are seen in a controlled learning environment. This would also provide a possible source of better referral of needed patients into a study such as this if it was established on a continuing basis.

This study also requires in the future the addition of control groups. One such group could be a match set of long term PMMA wearers who are not being refit but similar data would be collected at similar time intervals. In this study both the best fit refit and gas permeable lenses were used. To differentiate a change in fit from the effect of fit combined with gas permeable lenses, one eye could be refit with best fit PMMA lense parameters and the other eye refit with the best fit gas permeable material so that the patient serves as his own control. This may not be advisable in the more severely exhausted corneas. Another way to establish a control group would be to simply refitting only one eye with a gas permeable lens or best fit PMMA lens leaving the other eye wearing the old PMMA lens.

Other experiments in regards to refitting long term PMMA wearers would be to compare the efficacy of one gas permeable lense material to another given the data derived from the above additional experiments. Finally, to determine if stability has been established with the best fit gas permeable lens, it would be of great interest to determine what changes follow discontinuation of wear of theses lenses for a period of time.

APPENDIX I

STANDARD Rx-56 LENS PARAMETERS

Base Curve	ICR	PCR	Blend	Base Curve/Diameter
5.50	7.20	8.50	5.90	52.00/8.5
5.60	7.30	8.60	6.00	51.50/8.5
5.70	7.40	8.70	6.10	51.00/8.7
5.80	7.50	8.80	6.20	50.50/8.7
5.90	7.60	8.90	6.30	50.00/8.7
6.00	7.70	9.00	6.40	49.50/8.8
6.10	7.80	9.10	6.50	49.00/8.8
6.20	7.90	9.20	6.60	48.50/8.8
6.30	8.00	9.30	6.70	48.00/8.9
6.40	8.10	9.40	6.80	47.50/9.0
6.50	8.20	9.50	6.90	47.00/9.0
6.60	8.30	9.60	7.00	46.50/9.1
6.70	8.40	9.70	7.10	46.00/9.1
6.80	8.50	9.80	7.20	45.50/9.1
6.90	8.60	9.90	7.30	45.00/9.3
7.00	8.70	10.00	7.40	44.50/9.3
7.10	8.90	10.25	7.50	44.00/9.3
7.20	9.10	10.50	7.60	43.50/9.4
7.30	9.40	11.00	7.70	43.00/9.4
7.40	9.50	11.25	7.80	42.50/9.4
7.50	9.60	11.25	7.90	42.00/9.5
7.60	9.80	11.50	8.00	41.50/9.5
7.70	10.10	12.00	8.10	41.00/9.5
7.80	10.20	12.00	8.20	40.50/9.5
7.90	10.30	12.25	8.30	40.00/9.6
8.00	10.40	12.25	8.40	39.50/9.6
8.10	10.50	12.50	8.50	39.00/9.6
8.20	10.60	12.50	8.60	38.50/9.7
8.30	10.70	13.00	8.70	38.00/9.7
8.40	10.90	13.00	8.80	37.50/9.7
8.50	11.20	13.50	8.90	37.00/9.8
8.60	11.30	13.50	9.00	36.50/9.8
8.70	11.60	14.00	9.10	36.00/9.8
8.80	11.90	14.00	9.20	
8.90	12.00	14.50	9.30	
9.00	12.00	14.50	9.40	

APPENDIX II

POST-REFRACTION and EQUIVALENT SPHERE

Date	Post-refraction		Equivalent Sphere	
	OD	OS	OD	OS
Subject AS				
12/01/81 P	-1.00-0.50x035	-0.50 D S	-1.25	-0.50
R (10)				
03/05/82	-0.75-0.25x029	0.00-0.50x015	-0.87	-0.25
D (5)				
03/12/82 (5)	0.00-0.25x125	0.00-0.50x005	-0.12	-0.25
03/22/82 (1)	+0.25 D S	+0.50-0.25x047	+0.25	+0.37
Subject GB				
11/01/73 P	-2.00 D S	-2.00 D S	-2.00	-2.00
01/06/82	+0.25-1.00x173	+0.50-0.50x015	-0.25	+0.25
R (6)				
02/22/82				
D (8.5)				
03/02/82 (10)	+0.50-0.50x045	0.00 D S	+0.25	0.00
03/09/82 (6)	-0.50-0.25x180	+0.25-0.75x010	-0.62	-0.12
03/16/82 (6.5)	+0.50-0.50x180	+0.75-0.50x023	+0.25	+0.50
04/20/82 (5.5)	-1.75-0.25x176	-0.75 D S	-1.87	-0.75
Subject SL				
07/28/61 P	-5.50-0.75x180	-5.50-1.75x165	-5.87	-6.37
11/28/81	-4.50-1.75x159	-4.50-1.75x015	-5.37	-5.37
R (13.5)				
03/08/82	-4.75-1.75x176	-2.75-0.75x047	-5.62	-3.12
D (12.5)				
03/16/82 (13.5)	-3.25-0.75x112	-3.00-1.25x058	-3.62	-3.62
03/25/82 (5)	-3.75-1.25x135	-3.75-0.50x070	-4.37	-4.00
04/21/82 (12)	-4.50-0.25x175	-3.50-0.50x065	-4.62	-3.75

P = Pre-contact lens wear data
R = Diagnostic refit session
D = Dispensed RX-56 lenses
( ) = Hours of C L wear at time of exam

APPENDIX II (cont.)

Date	Post-refraction		Equivalent Sphere	
	OD	OS	OD	OS
Subject TD				
?/ ?/70 P	-5.75-0.50x045	-5.75-0.25x135	-6.00	-5.87
11/19/81 R (7)	-5.25-1.00x020	-5.50-1.75x080	-5.75	-6.37
01/06/82 D (5.5)				
01/07/82 (8)				
01/08/82 (8.5)	-4.75-1.00x171	-3.25-0.75x174	-5.25	-3.62
01/11/82 (4)	-4.50-1.25x167	-3.25-1.25x042	-5.12	-3.87
01/13/82 (5)	-4.50-0.75x177	-3.50-0.50x057	-4.87	-3.75
01/18/82 (6)	-4.50-2.00x175	-3.75-1.00x035	-5.50	-4.25
02/02/82 (6)	-5.75-0.50x015	-4.00-0.75x035	-6.00	-4.37
02/09/82 (6.5)	-5.25-1.00x075	-4.00-0.50x076	-5.75	-4.25
02/16/82 (6)	-5.75-0.50x090	-4.50-0.75x074	-6.00	-4.87
03/02/82 (6)	-6.00-0.25x063	-4.75-0.25x022	-6.12	-4.87
03/16/82 (6.5)	-6.00-0.25x090	-4.00-1.00x075	-6.12	-4.50
04/17/82 (5)	-5.00-0.75x105	-4.25-0.50x070	-5.37	-4.50

P = Pre-contact lens wear data
R = Diagnostic refit session
D = Dispensed RX-56 lenses
( ) = Hours of C L wear at time of exam

APPENDIX III

Keratometry Data

Date	OD	OS
Subject AS		
12/01/81	43.87 @ 002/44.00 @ 092	43.87 @ 018/44.00 @ 108
03/05/82	44.25 @ 010/44.87 @ 100	43.00 @ 026/44.37 @ 116
03/12/82	43.00 @ 163/43.75 @ 073	43.87 @ 026/43.87 @ 116
03/22/82	43.25 @ 180/44.00 @ 090	43.00 @ 033/44.00 @ 123
Subject GB		
11/01/73	44.00 @ 180/44.50 @ 090	44.25 @ 180/44.75 @ 090
01/06/82	43.00 @ 057/43.37 @ 147	43.25 @ 174/43.37 @ 084
02/22/82	43.37 @ 003/43.87 @ 093	43.62 @ 177/43.75 @ 087
03/02/82	42.50 @ 170/43.50 @ 080	43.50 @ 017/44.00 @ 107
03/09/82	42.50 @ 170/43.50 @ 080	43.37 @ 022/44.00 @ 112
03/16/82	42.75 @ 175/43.37 @ 085	43.25 @ 025/43.75 @ 115
04/20/82	42.87 @ 010/43.25 @ 100	43.50 @ 007/44.12 @ 097
Subject SL		
07/28/61	47.25 @ 170/48.75 @ 080	47.25 @ /49.50 @
11/28/82	45.87 @ 158/47.12 @ 068	45.87 @ 028/46.62 @ 118
03/08/82	44.25 @ 158/46.37 @ 068	45.00 @ 028/46.00 @ 118
03/16/82	45.50 @ 143/46.00 @ 053	45.00 @ 033/46.00 @ 123
03/25/82	46.37 @ 135/47.00 @ 045	46.62 @ 035/47.62 @ 125
04/21/82	45.75 @ 148/46.75 @ 058	46.00 @ 024/46.87 @ 114
Subject TD		
?/ ?/70	45.62 @ 180/45.75 @ 090	45.75 @ 180/45.75 @ 090
11/19/81	45.00 @ 178/44.87 @ 088	44.37 @ 002/44.50 @ 092
01/06/82		
01/07/82	44.00 @ 174/44.50 @ 084	43.75 @ 006/43.87 @ 096
01/08/82	44.12 @ 174/44.00 @ 084	42.75 @ 013/43.62 @ 103
01/11/82	43.00 @ 012/43.87 @ 102	42.25 @ 009/43.25 @ 099
01/13/82	43.00 @ 020/44.25 @ 110	42.87 @ 008/43.87 @ 098
01/18/82	43.62 @ 012/44.00 @ 102	43.12 @ 003/44.00 @ 093
02/02/82	43.87 @ 025/45.00 @ 115	43.50 @ 026/43.87 @ 116
02/09/82	44.87 @ 178/45.12 @ 088	43.87 @ 013/44.37 @ 103
02/16/82	44.37 @ 010/44.87 @ 100	44.00 @ 045/44.25 @ 135
03/02/82	44.25 @ 033/45.00 @ 123	43.75 @ 049/44.00 @ 139
03/16/82	44.50 @ 006/45.25 @ 096	44.00 @ /44.00
04/17/82	44.12 @ 010/45.00 @ 100	43.50 @ 006/44.00 @ 096

APPENDIX IV

Comparison of Refractive Cylinder and Corneal Toricity Found by the Keratometer and Corneascope

Date	Refractive Cylinder		Keratometer Delta K		Corneascope Delta K	
Subject AS	OD	OS	OD	OS	OD	OS
12/01/81	0.50	0.00	0.12	0.12	0.00	0.33
03/05/82	0.25	0.50	0.62	1.37	0.58	0.00
03/12/82	0.25	0.50	0.37	0.00	0.39	0.38
03/22/82	0.00	0.25	0.75	1.00	0.17	0.00
Subject GB						
11/01/73	0.00	0.00	0.50	0.50		
01/06/82	1.00	0.50	0.37	0.12	1.16	0.39
02/22/82			0.50	0.12	0.22	0.16
03/02/82	0.50	0.00	1.00	0.50	0.43	0.28
03/09/82	0.25	0.75	1.00	0.62	0.60	0.06
03/16/82	0.50	0.50	0.62	0.50	0.92	0.16
04/20/82	0.25	0.00	0.37	0.62	0.23	0.12
Subject SL						
07/28/61	0.75	1.75	1.50	2.25		
11/28/82	1.75	1.75	1.25	0.75	1.22	0.48
03/08/82	1.75	0.75	2.12	1.00	0.98	0.07
03/16/82	0.75	1.25	0.50	1.00	0.18	0.24
03/25/82	1.25	0.50	0.62	1.00	0.57	0.07
04/21/82	0.25	0.50	1.00	1.00	0.58	0.06
Subject TD						
?/ ?/70	0.50	0.25	0.12	0.00		
11/19/81	1.00	1.75	0.12	0.12	0.75	0.25
01/06/82					0.25	0.25
01/07/82	0.50	0.12	0.50	0.12	0.25	0.25
01/08/82	1.00	0.75	0.12	0.87	0.32	0.41
01/11/82	1.25	1.25	0.87	1.00	0.31	0.60
01/13/82	0.75	0.50	1.25	1.00	0.87	0.81
01/18/82	2.00	1.00	0.37	0.87	0.68	0.61
02/02/82	0.50	0.75	1.12	0.37	0.43	0.78
02/09/82	1.00	0.50	0.25	0.50	0.68	0.33
02/16/82	0.50	0.75	0.50	0.25	0.00	0.12
03/02/82	0.25	0.25	0.75	0.25	0.70	0.11
03/16/82	0.25	1.00	0.75	0.00	0.41	0.17
04/17/82	0.75	0.50	0.87	0.50	0.18	0.11

APPENDIX V

Contact Lens Parameters

Subject	Lens	BCR/Diopter	OAD/OZD	Power	CT
AS--OD	P	7.64/44.18	8.7/7.4	-2.25	0.17
	D	7.66/44.06	9.2/7.7	-0.87	0.21
	C	7.71/43.66	/7.87		
	O	7.58/44.53	9.2/7.7	-1.50	0.21
	R	7.62/44.29	9.1/7.2	-1.37	0.22
		X 7.67/44.00			
OS	P	7.64/44.18	8.6/7.4	-2.12	0.18
	D	7.66/44.06	9.2/7.7	-0.87	0.21
	C	7.78/43.38	/7.85		
	O	7.58/44.53	9.2/7.7	-2.00	0.21
	R	7.65/44.12	9.2/7.2	-2.00	0.22
GB--OD	P	7.68/44.95	8.9/7.4	-2.37	0.15
	D	7.66/44.06	8.8/7.8	-3.75	0.19
	C	7.82/43.16	/7.93		
	O	7.71/43.77	9.2/7.8	-2.50	0.20
	R	7.78/43/38	9.2/7.8	-2.25	0/21
		X 7.82/43.16			
OS	P	7.68/44.95	8.8/7.4	-1.50	0.18
	D	7.63/44.23	9.2/7.8	-3.00	0.19
	C	7.88/42.83	/7.85		
	O	7.58/44.53	9.2/7.8	-1.25	0.20
	R	7.71/43.77	9.0/7.5	-1.12	0.20
		X 7.76/43.49			
SL--OD	P	7.23/46.68	8.5/7.2	-5.25	0.13
	D	7.11/47.50	9.0/7.5	-3.00	0.19
	C	7.30/46.23	/7.58		
	O	7.07/47.74	9.0/7.5	-6.25	0.19
	R	7.08/47.67	9.0/7.5	-6.50	0.15
		X 7.15/47.20			
OS	P	7.21/46.81	8.6/7.2	-5.25	0.13
	D	7.11/47.50	9.0/7.5	-3.00	0.19
	C	7.25/46.55	/7.43		
	O	7.07/47.74	9.0/7.5	-6.50	0.19
	R	7.10/47.54	9.0/7.7	-6.62	0.14

P = Pre-refit PMMA Lens parameters
D = Diagnostic lens parameters
C = Corneascope suggested lens parameters
O = Ordered Rx-56 lens parameters
R = Received Rx-56 lens from manufacturer and dispensed

APPENDIX V (cont.)

Subject	Lens	BCR/Diopter	OAD/OZD	Power	CT
TD--OD	P	7.35/45.92	8.7/7.1	-7.50	0.09
	D	7.52/44.88	9.2/7.7	-3.12	0.21
		X 7.58/44.53			
	C	7.63/44.25	/7.63		
	O	7.52/44.88	9.2/7.7	-5.00	0.21
	R	7.54/44.76	9.3/8.0	-5.00	0.17
OS	P	7.39/45.67	8.8/7.2	-7.25	0.10
	D	7.65/44.12	9.2/7.5	-3.00	0.20
	C	7.72/43.75	/7.69		
	O	7.65/44.12	9.2/7.5	-4.50	0.20
	R	7.68/43.94	9.2/7.7	-4.50	0.17

P = Pre-refit PMMA lens parameters
D = Diagnostic lens parameters
C = Corneascope suggested lens parameters
O = Ordered Rx-56 lens parameters
R = Received Rx-56 lens from manufacturer and dispensed

APPENDIX VI

Lacrimal--Reference Line Trends

Date	OD	OS	Date	OD	OS
Subject AS			**Subject GB**		
12/01/81 P	1.1	1.0	01/06/82 P	1.1	1.0
02/16/82 D	1.1	1.1	02/05/82 D	1.8	1.1
03/05/82 R	1.1	2.0	02/22/82 R	1.2	1.2
03/12/82	1.3	2.0	03/02/82	1.5	1.3
03/22/82	1.1	2.0	03/09/82	1.5	1.0
			03/16/82	1.4	1.2
			04/20/82	1.4	1.7
Subject SL			**Subject TD**		
11/28/81 P	0.6	0.6	11/19/81 P	1.5	1.5
02/16/82 D	1.4	1.4	12/05/81 D	1.3	1.4
03/08/82 R	1.3	2.0	01/06/82 R	1.7	1.1
03/10/82	1.1	1.5	01/07/82	2.0	2.0
03/16/82	1.0	0.9	01/08/82	1.5	2.0
03/25/82	1.5	1.8	01/11/82	1.5	1.3
04/21/82	1.4	2.0	01/13/82	1.5	1.3
			01/18/82	1.7	1.4
			02/02/82	1.8	1.5
			02/09/82	1.3	1.5
			02/16/82	1.3	1.3
			03/02/82	1.2	1.6
			03/16/82	1.1	1.3
			04/17/82	1.5	1.6

P = Pre-refit PMMA lens
D = Diagnostic Rx-56 lens
R = Received and dispensed Rx-56 lens

APPENDIX VII

Corneascope Data

Date		H_3	V_3	H_9
Subject AS	OD			
12/01/81		7.73/43.66	7.73/43.66	7.86/42.94
03/05/82		7.69/43.89	7.59/44.47	7.86/42.94
03/12/82		7.83/43.10	7.76/43.49	7.89/42.78
03/22/82		7.87/42.88	7.84/43.05	7.91/42.67
	OS			
12/01/81		7.87/42.88	7.81/43.21	7.87/42.88
03/05/82		7.91/42.67	7.91/42.67	7.96/42.40
03/12/82		8.01/42.99	7.94/42.51	7.98/42.29
03/22/82		7.85/42.99	7.85/42.99	7.90/42.72
Subject GB	OD			
01/06/82		7.93/42.56	7.90/43.72	7.92/42.61
02/22/82		7.88/42.83	7.84/43.05	7.94/42.51
03/02/82		8.05/41.92	7.97/42.35	8.00/42.19
03/09/82		7.93/42.56	7.82/43.16	7.93/42.56
03/16/82		7.96/42.40	7.79/43.32	7.90/42.72
04/20/82		7.82/43.16	7.78/43.38	7.81/43.10
	OS			
01/06/82		7.84/43.05	7.77/43.44	7.84/43.05
02/22/82		7.88/42.83	7.85/42.99	7.95/42.45
03/02/82		7.87/42.88	7.82/43.16	7.85/42.99
03/09/82		7.79/43.32	7.78/43.38	7.78/43.38
03/16/82		7.87/42.88	7.84/43.04	7.87/43.16
04/20/82		7.79/43.32	7.77/43.44	7.82/43.16
Subject SL	OD			
11/28/81		7.54/44.76	7.34/45.98	7.60/44.41
03/08/82		7.49/45.06	7.33/46.04	7.42/45.49
03/16/82		7.36/45.86	7.33/46.04	7.44/45.36
03/25/82		7.34/45.98	7.25/46.55	7.44/45.36
04/21/82		7.31/46.17	7.22/46.75	7.45/45.30
	OS			
11/28/81		7.43/45.42	7.34/45.98	7.42/45.48
03/08/82		7.37/45.79	7.36/45.86	7.28/46.36
03/16/82		7.42/45.48	7.46/45.24	7.43/45.42
03/25/82		7.24/46.62	7.25/46.55	7.34/45.98
04/21/82		7.25/46.55	7.26/46.49	7.35/45.92

H_3 = Horizontal meridian at Comparator's 3rd ring
H_9 = Horizontal meridian at Comparator's 9th ring
V_3 = Vertical meridian at Comparator's 3rd ring

APPENDIX VII (cont.)

Date	H_3	V_3	H_9
Subject TD OD			
11/19/81	7.74/43.50	7.60/44.25	7.63/44.25
01/06/82	7.72/43.75	7.77/43.50	7.72/43.75
01/07/82	7.85/43.00	7.79/43.32	7.79/43.42
01/08/82	7.77/43.44	7.72/43.75	7.73/43.75
01/11/82	7.87/42.88	7.72/43.75	7.64/44.18
01/13/82	7.78/43.38	7.66/44.06	7.73/43.66
01/18/82	7.79/43.32	7.57/44.58	7.67/43.75
02/02/82	7.78/43.38	7.66/44.06	7.68/43.94
02/09/82	7.62/44.29	7.62/44.29	7.68/43.94
02/16/82	7.70/43.83	7.58/44.53	7.70/43.83
03/02/82	7.67/44.00	7.60/44.41	7.68/43.94
03/16/82	7.63/44.23	7.60/44.41	7.69/43.89
04/17/82	7.75/43.54	7.73/43.75	7.75/43.54
OS			
11/19/81	7.66/44.00	7.67/43.75	7.66/44.00
01/06/82	7.58/44.50	7.61/44.25	7.67/43.75
01/07/82	8.00/42.19	7.92/42.61	7.74/43.60
01/08/82	7.90/42.72	7.79/43.32	7.70/43.83
01/11/82	8.03/42.02	7.88/42.83	7.75/43.54
01/13/82	7.87/42.88	7.76/43.49	7.73/43.66
01/18/82	7.87/42.88	7.73/43.66	7.72/43.71
02/02/82	7.82/43.16	7.76/43.49	7.72/43.71
02/09/82	7.72/43.72	7.69/43.89	7.69/43.89
02/16/82	7.69/43.89	7.67/44.00	7.70/43.83
03/02/82	7.67/44.00	7.70/43.83	7.63/44.23
03/16/82	7.70/43.83	7.72/43.72	7.70/43.83
04/17/82	7.79/43.32	7.75/43.54	7.73/43.66

H_3 = Horizontal meridian at Comparator's 3rd ring

V_3 = Vertical meridian at Comparator's 3rd ring

H_9 = Horizontal meridian at Comparator's 9th ring

APPENDIX VIII

Pachometry Data

Subject AS — OD

Lens	Temporal 9	8	7	6	Fixation Points 1	2	3	4	Nasal 5	Date
p(10)	.7293	.6237	.6077	.5922	.6739	.6360	.6382	.7179	.7983	12/01/81
d(5)	.6533	.5854	.5608	.5439	.5429	.5812	.5955	.5569	.7220	03/05/82
r(5)	.6412	.6008	.5399	.5335	.5238	.5513	.5962	.6455	.7462	03/12/82
r(1)	.6405	.6052	.5439	.5229	.5327	.5501	.5778	.6645	.7104	03/22/82

OS

Lens	Nasal 9	8	7	6	Fixation Points 1	2	3	4	Temporal 5	Date
p(10)	.7477	.6715	.6061	.5685	.5489	.5485	.5871	.6483	.7464	12/01/81
d(5)	.7223	.6791	.5930	.5672	.5244	.5333	.5515	.5781	.6417	03/05/82
r(5)	.7389	.6689	.5752	.5395	.5264	.5169	.5371	.5679	.6242	03/12/82
r(1)	-----	.6368	.5909	.5301	.5176	.5232	.5283	.5560	.6426	03/22/82

Subject GB — OD

Lens	Temporal 9	8	7	6	Fixation Points 1	2	3	4	Nasal 5	Date
p	.6311	.6244	.5763	.5778	.5415	.6098	.6074	.6954	.7527	01/06/82
d(8½)	.6385	.5630	.5414	.5548	.5326	.5193	.5521	.5925	.7015	02/22/82
r(10)	.6053	.5435	.5363	.5001	.4923	.5046	.5307	.6011	.6790	03/02/82
r(6)	.5978	.5616	.5196	.5011	.5037	.5183	.5487	.5917	.6672	03/09/82
r(6½)	.6125	.5809	.5277	.5059	.5292	.5044	.5434	.5854	.6761	03/16/82
r(5½)	.6060	.5505	.5201	.5043	.5059	.5086	.5539	.6073	.6715	04/20/82

OS

Lens	Nasal 9	8	7	6	Fixation Points 1	2	3	4	Temporal 5	Date
p	.7146	.6592	.6540	.6253	.5424	.5519	.5879	.6199	.6570	01/06/82
d(8½)	.6650	.5764	.6181	.5367	.5139	.4960	.5350	.5463	.5661	02/22/82
r(10)	.6595	.6081	.5560	.5322	.5152	.5160	.5270	.5461	.5845	03/02/82
r(6)	Instr. Failure--------				.5151	.5067	.5244	.5532	.6045	03/09/82
r(6½)	.6779	.5918	.5562	.5236	.5335	.5236	.5447	.5417	.6171	03/16/82
r(5½)	.6822	.6255	.5768	.5483	.5147	.5164	.5349	.5425	.5945	04/20/82

Subject SL — OD

Lens	Temporal 9	8	7	6	Fixation Points 1	2	3	4	Nasal 5	Date
p(3½)	.5694	.5357	.5046	.5102	.4915	.5167	.5163	.5806	.6917	11/28/81
d(12½)	.5101	.4949	.4677	.4353	.4211	.4288	.4714	.5138	.5938	03/08/82
r(13½)	.5236	.4912	.4375	.4226	.4185	.4371	.4874	.5029	.5730	03/16/82
r(5)	.5259	.4944	.4778	.4397	.4388	.4378	.4543	.4873	.5645	03/25/82
r	.5239	.4845	.4590	.4316	.4226	.4493	.4733	.5215	.5935	04/21/82

OS

Lens	Nasal 9	8	7	6	Fixation Points 1	2	3	4	Temporal 5	Date
p(3½)	.5849	.5197	.5472	.4703	.5046	.4615	.5005	.5251	.6078	11/28/81
d(12½)	.5224	.5237	.4585	.4338	.4340	.4135	.4662	.4908	.5179	03/08/82
r(13½)	.4423	.4962	.4636	.4589	.4174	.4088	.4360	.4830	.5120	03/16/82
r(5)	.5816	.4970	.4733	.4421	.4425	.4147	.4423	.4776	.5236	03/25/82
r	.6039	.5246	.4678	.4601	.4329	.4146	.4500	.4727	.5344	04/21/82

p=prefit data d=dispense data r=RX-56 lense ( )=hours of wear

APPENDIX VIII (cont.)

Subject TD

OD

Lens	Temporal			Fixation Points					Nasal	Date
	9	8	7	6	1	2	3	4	5	
p(7)	.5615	.5311	.4808	.4887	.4821	.4951	.5310	.5300	.6310	11/19/81
d(5½)	.5264	.5069	.4925	.4701	.4698	.4738	.5056	.5060	.5349	01/06/82
r(8)	.5764	.5061	.4959	.4445	.4535	.4492	.4901	.5277	.5771	01/07/82
r(8½)	.5552	.5306	.4947	.4732	.4548	.4856	.4958	.5198	.5624	01/08/82
r(4)	.5462	.5288	.5050	.4482	.4856	.4990	.4871	.5209	.5828	01/11/82
r(5)	.5578	.5192	.4708	.4628	.4424	.4530	.4690	.5263	.5757	01/13/82
r(6)	.5681	.5120	.5041	.4747	.4395	.4607	.4942	.5120	.5559	01/18/82
r(6)	.5262	.4925	.4499	.4228	.4342	.4669	.4710	.5058	.5458	02/02/82
r(6½)	.5380	.4927	.4625	.4416	.4309	.4557	.4902	.5023	.5437	02/09/82
r(6)	.5161	.4912	.4487	.4309	.4274	.4390	.4716	.4955	.5367	02/16/82
r(6)	.5776	.4862	.4474	.4287	.4220	.4328	.4712	.5016	.5356	03/02/82
r(6½)	.5366	.5003	.4692	.4448	.4438	.4405	.4681	.5063	.5801	03/16/82
r(5)	.5440	.4953	.4475	.4304	.4287	.4287	.4722	.4930	.5351	04/17/82

OS

Lens	Nasal			Fixation Points				Temporal		Date
	9	8	7	6	1	2	3	4	5	
p(7)	.6695	.5797	.5153	.4815	.4670	.4887	.5027	.5368	.5662	11/19/82
d(5½)	.5048	.5265	.4926	.4755	.4720	.4667	.4779	.5033	.5389	01/06/82
r(8)	.6119	.5271	.4959	.4597	.4685	.4519	.4923	.5112	.5535	01/07/82
r(8½)	.5944	.5260	.4987	.4662	.4402	.4458	.4678	.5133	.5523	01/08/82
r(4)	.5864	.5402	.5058	.4830	.4605	.4484	.4886	.5063	.5378	01/11/82
r(5)	.5883	.5237	.5005	.4652	.4688	.4432	.4697	.5060	.5401	01/13/82
r(6)	.6548	.5268	.5075	.4555	.4356	.4534	.4832	.5127	.5321	01/18/82
r(6)	.6175	.5197	.4796	.4398	.4508	.4198	.4533	.4761	.5082	02/02/82
r(6½)	.6171	.5184	.4859	.4295	.4237	.4324	.4548	.4891	.5212	02/09/82
r(6)	.5614	.5131	.4806	.4440	.4362	.4229	.4450	.5017	.5203	02/16/82
r(6)	.5591	.5016	.4865	.4446	.4179	.4252	.4524	.4817	.5232	03/02/82
r(6½)	.6040	.4962	.4915	.4578	.4243	.4440	.4500	.4852	.5374	03/16/82
r(5)	.5542	.5233	.4677	.4334	.4186	.4224	.4446	.4817	.5380	04/17/82

p=prefit data d=dispense data r=Rx-56 lense ( )=hours of wear

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