The Effect of Varying Contact Lens Power on Goldmann Tonometry Readings
Senior Project
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Abstract: Using Goldmann tonometry, twenty eyes were measured for intraocular pressure with and without Acuvue 2 soft contact lenses. Four different lens powers (+3.00D, -3.00D, +1.50D, and -1.50D) were utilized during the study. The intent was to see the effect soft contact lenses had on Goldmann IOP measurements. Furthermore, the effect of varying contact lens power and IOP measurement was also evaluated. The end result showed that the power of the lens and the presence of the lens itself on the eye had no significant effect on tonometry readings.

Introduction: The soft contact lens is a versatile medical device available to the optometrist. Along with correcting refractive error, the soft lens is useful as a bandage in cases of corneal trauma or erosion. It is also vehicle for the delivery of ophthalmic pharmaceuticals. When a soft lens is placed in solution it absorbs the pharmaceutical and when placed on the eye it slowly releases the drug. With the overwhelming popularity of the soft contact lens, the convenience of continually having the patient remove their lenses for tests such as tonometry is called into question. Cases may be encountered where removing the lenses is not desirable, particularly when dealing with corneal trauma or severe erosions. In addition, with the ever-changing world of glaucoma and uveitis treatment, it is feasible that therapeutic lens use could attempt to maintain continuous levels of medication at the contact lens/cornea interface. In both situations, tonometry readings may need to be taken with the soft lenses on.

This study hypothesizes that a soft contact can appreciably effect intraocular pressure measurement and furthermore it may be possible to predict how large of an effect based on the lens power. With increased contact lens thickness, increased pressure measurements are expected.

Methods: To study the effect a soft contact lens has on Goldmann tonometry readings, twenty eyes were measured with and without soft contact lenses. The contact lenses used in the research were Acuvue 2 lenses of four different powers. The twenty eyes had no prior diagnosis of glaucoma or any other ocular disease. Four subsets of subjects were created. Patients in the study wore one of four dioptric powers: -1.50D, +1.50D, -3.00D, and +3.00D. The Acuvue 2 lens is a group four lens (high water/ionic polymer) made of 42% etafilcon A and 58% water. The lenses used in the research had a base curve of 8.7mm and a diameter of 14.0mm. Center thickness varied with lens power. The center thickness ranged from .17mm (+3.00D) to .084mm (-3.00D).1

The initial tonometry reading was performed after instillation of one drop of 0.5% proparacaine. Intraocular pressures were measured with a Goldmann tonometer mounted on a Haag-Streit slit lamp without the use of the cobalt blue filter. The second reading was taken one day later and at the same time to eliminate the effect of any diurnal variation. The patient inserted the lens and then allowed it to settle for five minutes to avoid any artificial elevation or reduction of the IOP secondary to insertion. Applanation was performed over the contact without the aid of anesthetic or cobalt blue filter so the mire pattern would mimic the appearance of the mires in the initial measurement.

In an effort to further reduce any variability, all Goldmann tonometry readings were taken on the same Haag-Streit slit-lamp and by the same clinician. Fluorescein, which is typically used in applanation tonometry to visualize mires, was not used because of secondary staining to soft contacts. In order to maintain consistency between the two test groups, dye was not used in the initial reading.

Measurements from each patient were recorded and assessed for any significant difference between the two intraocular pressures. The results were grouped by lens power and a mean change in pressure was calculated. Paired t-tests were run on each lens group to ascertain if there was any statistically significant difference (significance - $p<0.05$) between the intraocular pressures taken with and without the contact lenses.

Results: The data given here correlates with tables 1 and 2.

Group 1 (-1.50D): The overall mean difference between intraocular pressure measurements revealed an average increase of +0.6mmHg and a standard deviation of 2.19. Statistical analysis on this data group resulted in a p-value of .5734 and a t-ratio of .61. Both of these results indicate no statistical significance between pressures taken with and without the -1.50 Acuvue 2 lens.

Group 2 (-3.00D): This group's decreased an average of 0.8mmHg while wearing the lenses (standard deviation=5.36). However, the statistical analysis indicated no significance with the findings (p=. 7552 and t=. 3389).

Group 3 (+1.50D): The data indicated an average decrease in intraocular pressure of 0.4mmHg (standard deviation=1.52). Once again, the analysis showed no significant difference between the pressure readings with and without the soft lenses (p=. 5870 and t=. 5898).

Group 4 (+3.00D): This group revealed the largest mean difference between pressure measurements, an average increase of 1.8mmHg and a standard deviation of 3.99. Analysis revealed the differences to be marginally closer to significant than the previous three groups. However, these measurements were also proven not to be significant at the 5% level (p=. 3602 and t=1.0324).

As a whole, the entire group of twenty cases indicated an average increase of +0.3mmHg (p=. 7005 and t=. 3906) which is seemingly insignificant for intraocular pressure readings.*

Discussion: The results showed a lack of consistency, with two lenses (+3.00 and -1.50) producing an overall increase in the intraocular pressure and two lenses (-3.00 and +1.50) showing an overall decrease. The hypothesis was that with increasing center thickness there would be a corresponding increase in the measured intra-ocular pressure. While the thickest lens (+3.00D) did show the largest effect on pressure (+1.8mmHg) the next thickest lens (+1.50D) showed the smallest effect and a reduction in pressure at that (-0.4mmHg).

The fact that the contact lenses as a whole did not produce a significant change in intraocular pressure measurements is not as surprising. A study using soft contacts on cadaver eyes and other methods of tonometry (non-contact and tonopen) revealed that contact lens thickness provided some influence on the measured pressure, but that effect was minor.2 This same study used four different brands of contacts with center thicknesses ranging from 0.30mm to 0.035mm. Thickness was accountable for only an influence of 0.09% on the measured IOP.2 However, this group did not use the Goldmann method of tonometry and offered no information on the power of the contact lenses and whether there was any variation in the dioptric power used.

The Kreda study in 1987 used Goldmann tonometry over a variety of brands and powers of soft contacts and came to several conclusions. Tonometric findings obtained over soft contacts were not significantly different from those obtained without contacts. Conversely, Kreda did indicate that thicker lenses do resist applanation and may cause some falsely high pressure readings.3 Kreda's data indicates the largest difference in intraocular pressures was found when high plus lenses (+5.00D and higher) were used on the patients.3

The scatter of the results raises several questions. First, why do some individuals show marked increases in pressures while others wearing the same lenses actually show a decrease? Placing a contact lens on a cornea would logically seem to create an artificially thicker cornea and in past studies increased thickness led to significant overestimations of intraocular pressure.4 An average central corneal thickness is estimated to fall between 0.49mm and 0.56mm5 and departure from this can affect the IOPs. In this study the pressures were being measured through artificially thickened corneas. It seems in this situation pressures would always appear higher or at the very least unchanged.

One possible cause of error may be due to the inherent difficulty in assessing the mires with the Goldmann tonometer when no fluorescein (and consequently no cobalt filter) is used. The blue-green contrast with the dye and filter give relative ease in assessing when proper applanation has been achieved. It is more difficult to determine when the proper mire configuration is attained without fluorescein and the blue filter. As a result, measurements of pressure may not be as accurate. From this study it became apparent that obtaining accurate pressure measurements requires some increased level of skill. Furthermore, high water lenses such as the Acuvue 2 tend to give a solid rather than ring pattern with applanation.3 This, too, causes a problem in trying to obtain accurate pressures. Fluorexon, a dye mimicking the properties of fluorescein, does not stain soft lenses and can make assessing applantion easier.3 Fluorexon was not available to this study.

Another possibility revolves around the contact lenses themselves and their fitting relationship to the cornea. This study assumed a proper lens fit. Perhaps if the contact is too steep it may vault off the cornea to the point that it can cause an underestimation of pressure. A flat fitting minus lens may create a situation where the contact drops significantly and applanation occurs against the thicker lens periphery, thereby overestimating the IOP.

Conclusion: The results found in this study would indicate that Goldmann applanation tonometry performed through contact lenses, on average, does not significantly effect the intraocular pressure reading regardless of the lens power. Consequently, one could perform this procedure with some measure of confidence in the results that were obtained. However, at this point it appears difficult to predict with any accuracy what kind of effect individual lens power might have in individual tonometry readings.

There are several findings that would indicate the need for further study in this area. For starters, the large standard deviations (particularly on the -3.00D and +3.00D groups) indicate more measurements on more individuals need to be taken to see if the large variance is typical. Building on that, more individuals need to be seen in hopes of increasing practitioner skill with the procedure thereby increasing confidence that the readings obtained are correct. Another area worthy of further research would be correlating these results with pachymetry findings on the patients to see whether the addition of lenses creates an artificial corneal thickness that falls in or outside of the normal range. Corneas outside the normal range may show increased pressure readings. Finally, a relationship between the intraocular pressures and the quality of the lens fit should be addressed. It is probable to hypothesize that the better the fit, the more consistent the readings with what was expected.

It is clear that further study is necessary before any definitive answers can be given in this area of optometric study.

Table 1

Lens Power	IOP w/CL	IOP w/out CL	IOP Change
-1.50D	10mmHg	10mmHg	0
	10mmHg	8mmHg	-2
	8mmHg	12mmHg	4
	14mmHg	15mmHg	1
	10mmHg	10mmHg	0
-3.00D	12mmHg	8mmHg	-4
	7mmHg	12mmHg	5
	7mmHg	12mmHg	5
	12mmHg	8mmHg	-4
	14mmHg	8mmHg	-6
+1.50D	12mmHg	10mmHg	-2
	13mmHg	13mmHg	0
	9mmHg	10mmHg	1
	11mmHg	12mmHg	1
	16mmHg	14mmHg	-2
+3.00D	14mmHg	12mmHg	-2
	14mmHg	14mmHg	0
	13mmHg	12mmHg	-1
	14mmHg	20mmHg	6
	15mmHg	21mmHg	6

Table 2

	mean IOP change	standard deviation	p-value	t-value
-1.50D	0.6	2.19	0.5739	0.61
-3.00D	-0.8	5.36	0.7552	0.3339
+1.50D	-0.4	1.52	0.587	0.5898
+3.00D	1.8	3.99	0.3602	1.0324

References:

1. Tyler's Quarterly Soft Contact Lens Parameter Guide. March 2000. Volume 17 Number 2. pg. 9
2. Mark L, Asbell P, Torres M, Failla S: Accuracy of Intraocular Pressure Measurements with Two Different Tonometers Through Bandage Contact Lenses. Cornea. 1992 Jul; 11 (4): 277-81
3. Kreda, Sheldon: Applanation Tonometry in Contact Lens Practice. Journal of the American Optometric Association. 1987 Mar; 58 (3): 208-10
4. Whitacre M, Stein R, Hassanein K: The Effect of Corneal Thickness on Applanation Tonometry. American Journal of Ophthalmology. 1993 May 15; 115 (5):592-6
5. Kanski, JJ. Clinical Ophthalmology-A Systemic Approach. 3rd ed. Reed Educationa and Professional Publishing Ltd. 1997; pg. 102

* Statistical calculations aided by www.graphpad.com