

THE EFFECTS OF SILICONE HYDROGELS ON INTRAOCULAR PRESSURE
MEASUREMENTS

by

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ABSTRACT

Purpose: To determine the similarity of intraocular pressure (IOP) measurements taken by non-contact tonometry (NCT) and Tono-Pen tonometry over a silicone hydrogel contact lens compared to Goldmann applanation tonometry (Goldmann) without a contact lens on the eye.

Methods: Twenty-six healthy volunteers (52 eyes) participated in this study. Intraocular pressure measurements were taken first through NCT. One investigator performed all NCT measurements. Following topical anesthesia, IOP was then taken with Goldmann applanation tonometry and the Medtronic Tono-Pen XL. Goldmann and Tono-Pen readings were all gathered by one investigator, although not the same as who performed NCT. After insertion of a Ciba Focus Night and Day silicone hydrogel soft contact lens of minimal power, measurements were repeated with NCT and Tono-Pen without additional anesthetic.

Results: During this study, the average NCT and Tono-Pen IOP measurements without contacts lenses were lower than Goldmann applanation tonometry measurements. When a silicone hydrogel contact lens (Ciba Night and Day/-0.50 DS) was placed on the cornea and pressures were taken over the contact lens using NCT and Tono-Pen, the pressure measurements were additionally lower. Tono-Pen over a contact lens gave a reading

11.02% lower than the IOP measured by Goldmann. In comparison of Tono-Pen without a contact lens, readings were on average 1.98% lower over the hydrogel lens. In the same way, NCT over a contact lens measured the IOP to be an average of 13.06% lower than Goldmann. Compared to NCT without a contact lens, NCT pressures were on average 7.37% lower with a contact lens.

Conclusion: According to the data, tonometry readings taken with Tono-Pen over a silicone hydrogel lens are considered similar to measurements taken with Tono-Pen without a contact lens ($p=0.131$). Tonometry readings over a contact lens are not similar when taken with NCT ($p=.002$) or when compared to Goldmann pressure measurements.

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INTRODUCTION

In conditions of corneal compromise, bandage contact lenses are routinely used to provide comfort and protection. In the use of a lens for therapeutic application, consideration must be given to the necessity of overnight wear and prevention of further damage to a compromised cornea. Because epithelial healing is promoted in the presence of normal oxygen levels, the high Dk silicone hydrogel contact lenses have become the best option for therapeutic bandage contact lenses. In addition to minimizing hypoxia due to the high Dk material, these lenses also offer a low water content which helps to prevent dehydration and aid in surface wettability.¹ This adds to the appeal of using silicone hydrogel contact lenses as a bandage lens. Clinical conditions requiring the use of a bandage lens include trichiasis, bullous keratopathy, post graft or refractive surgery, corneal dystrophies, recurrent erosions, filamentary keratitis, and trauma preventing lid closure.¹

In some cases, intraocular pressure must be measured in the presence of the therapeutic lens. Goldmann applanation tonometry is not the procedure of choice in these cases because the fluorescein dye will stain the contact lens and the anesthetic may delay corneal healing. Non-contact tonometry (NCT) or Tono-Pen are two procedures that could safely be performed over a soft contact lens. Therefore, this study was designed to

determine the effect a silicone hydrogel contact lens has on the measurement of IOP with NCT and Tono-Pen instruments. Goldmann applanation tonometry readings are used as a control for this study.

METHODS

Twenty-six healthy volunteers, ages 21-35, participated in this study conducted by two investigators. A total of fifty two eyes were measured. Male and female volunteers were involved and none of the women were known to be pregnant. Informed consent was obtained from each subject. All measurements were taken with the patient in the sitting position. Initially, pneumotonometry was performed using an American Optical non-contact tonometer. Following installation of Fluress, fluorescein sodium and benoxinate hydrochloride ophthalmic solution, intraocular pressure was then taken by Goldmann applanation tonometry and with the Medtronic Tono-pen. All readings that were not within 5% accuracy as indicated on the Tono-Pen were discarded and the test was repeated. A Ciba Night and Day silicone hydrogel lens (8.6/-0.50 D/14.0 mm/0.095 mm) was then inserted in each eye of the participant. Both NCT and Tono-Pen measurements were repeated on each eye over the contact lens. One investigator took all the NCT measurements. All the Tono-Pen and Goldmann readings were measured by the other investigator. The five pressure readings were taken consecutively. A paired t-test was used to gather t values and p values.

RESULTS

Six sets of data were derived from this study allowing us to compare statistical relevance between Goldmann tonometry and Tono-Pen without contacts, Goldmann and NCT without contacts, Tono-Pen without contacts and Tono-Pen with contacts, NCT without contacts and NCT with contacts, Goldmann and Tono-Pen with contacts, and Goldmann and NCT with contacts. Due to the small sample size of 52 eyes, the paired *t*-test was employed to analyze the data. To avoid type I false positive errors, the level for statistical significance was set at $\alpha = 0.05$.

Table 1. Intraocular Pressure Comparison by Method

	t	p	Average Difference	Average Percent Difference
Tono-Pen to Goldmann	3.32	0.002	-1.15 mmHg	-6.94
NCT to Goldmann	2.13	0.038	-0.73 mmHg	-4.53
Tono-Pen over CL* to Tono-Pen	1.53	0.131	-0.58 mmHg	-1.98
NCT over CL to NCT	3.29	0.002	-1.21 mmHg	-7.37
Tono-Pen over CL to Goldmann	5.14	0.000	-1.73 mmHg	-11.02
NCT over CL to Goldmann	5.50	0.000	-1.94 mmHg	-13.06

*CL = contact lens

DISCUSSION

Goldmann applanation tonometry is considered the gold standard of obtaining a patient's IOP to date. There are, however, times when it is not appropriate to test IOP with the Goldmann method. One such time is when a patient is wearing a contact lens and fluorescein would stain the lens. If the contact lens is for therapeutic purposes, it may not be prudent to remove the lens at that time. If the pressure reading must be attained, it would be helpful to know a method other than Goldmann that would give accurate measurements over the contact lens.

As with all clinical tests, there are sources of error within Goldmann measurements.²

The rigidity of corneas and the thickness of corneas may effect pressure readings. This study changes both the rigidity and thickness of the measured surface by inserting a low powered myopic silicone hydrogel contact lens on the cornea. By inserting the contact lens, the surface is made thicker albeit by a small amount. The lens used in this study has a center thickness of .095 mm at a power of -0.50 D.

An earlier study showed when applanation tonometry is repeated, a decline in IOP measurements is shown.² In order to obtain our pressure readings for the study, we repeated applanation tonometry to gather a total of five measurements. It is possible that our readings over a contact lens are affected by this since those were the last of the measurements taken.

Despite its flaws, Goldmann is considered to be the gold standard at the time of this study and was designated as the control. After Goldmann was performed, Tono-Pen and NCT measurements without contact lenses were taken. Tono-Pen readings were an average of 1.15 mmHg (-6.94%) lower than Goldmann measurements ($p=0.002$). This p value is statistically significant at the 5% level. Interestingly, a study from 1992 showed that Tono-Pen was not accurate enough to compare to Goldmann.³ The average IOP measurements using NCT was .73 mmHg less (-4.53%) than Goldmann on average ($p=0.038$). This p value is also statistically significant at the 5% level.

Once the contact lens was placed on the eye, both Tono-Pen and NCT measurements were repeated. The Tono-Pen measurements with a lens were, on average, .56 mmHg less (-1.98%) than when the Tono-Pen was used without a contact lens ($p=0.131$). This p value is not statistically significant at the 5% level. Compared to Goldmann, Tono-Pen over a contact lens averaged a reading of 1.73 mmHg less (-11.02%) ($p=0.000$). This p value is significant at the 5% level.

NCT measurements over a contact lens were an average of 1.21 mmHg (-7.37%) less than NCT without a contact lens ($p=0.002$). Compared to Goldmann, NCT with a contact lens was 1.94mmHg less (-13.06%) on average ($p=0.000$). Both of these p values are statistically significant at the 5% level.

There was a significant range (0-7 mmHg difference) in our data points. However, all data was within 3 standard deviations and therefore no outliers were removed for

calculations. Despite the large range, 59.2% of data points were within +/- 2 mmHg and 77.6% were within +/-3 mm Hg.

Similar studies have been conducted in the past. A study from 2004 showed that non-contact tonometry over a contact lens is accurate if the center thickness is less than or equal to 0.30 mm and the power is less than or equal to +3.00 D.⁶ Another study showed IOP measurements over myopic lenses up to -15.00 D to be accurate.⁴ A similar study found that non-contact pneumotonometry over myopic and low-powered hypermetropic soft silicone hydrogel (Ciba Night and Day) contact lenses is reliable (+/-2 mmHg 78% of the time for -1.00 DS lenses).⁵ NCT was again found to be accurate over non-silicone hydrogel contact lenses in a study from 1991.⁶

CONCLUSION

The purpose of this study is to determine if the measurement of Tono-Pen and NCT readings is changed if the pressure measurements are taken over a silicone hydrogel bandage contact lens. The null hypothesis is that there is no statistically significant difference in intraocular pressure readings taken without wearing a contact lens compared to wearing a contact lens. If the p value is less than 0.05, the null hypothesis is rejected. It is recognized that the difference is caused by chance 5% of the time and caused by some other factor 95% of the time. If all other factors were held constant, the changed factor in this study would be a silicone hydrogel contact lens being placed on the eye. If the p value is greater than .05, the null hypothesis is accepted. The only p value that is not statistically significant at the 5% level is the comparison between Tono-Pen readings with and without contact lenses. According to this study, therefore, Tono-Pen readings over contact lenses are considered similar to measurements when compared to Tono-Pen readings without a contact lens. Tonometry readings over a contact lens are not similar when taken with NCT or when compared to Goldmann pressure measurements. This study does not attempt to determine the accuracy of Tono-Pen or NCT compared to Goldmann, although the data found that both Tono-Pen and NCT gave measurements lower than Goldmann.

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