TEMPERATURE UNDER CONTACT LENSES IN THE OPEN AND CLOSED EYE

SENIOR PROJECT

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INTRODUCTION

The human cornea, which is usually 3-5°C cooler than body temperature[1-3], has a wider normal temperature range than other parts of the body[4]. Although this range may be related to certain corneal metabolic characteristics, the transient tear film nature, and an exposed anterior location, the cornea relies heavily upon exogenous and/or environmental sources for its heat[4]. Corneal surface temperature raises in the presence of contact lenses, due to both the insulating effect of the plastic lens and the subsequent decreased evaporative cooling of tears[5]. This rise in corneal temperature stimulates a higher metabloic rate, thereby, changing corneal demand for oxygen and other metabolites necessary for maintaining a healthy contact lens - cornea relationship. For each 10°C increase in tissue temperature, there is a doubling of metabolic rate[6], therefore, even a 1 to 2°C rise in corneal temperature could significantly alter metabolism.

As different contact lens materials have different heat conductivities, the purpose of this study is to determine if a difference in corneal temperature exists under HEMA(poly hydroxyethylmetharcylate) lenses as compared to those made of silicon elastomer. We will use both high plus and standard thickness minus lenses to also investigate the effect of lens thickness differences. Temperature measurements will be made in both open and closed eye conditions.

METHODS

A thin hydrogel lens (Bausch and Lomb U4, -2.75D) was placed on the subjects' eye, with a bead microthermistor (0.014" diameter) between it and the various study lenses. A digital ohm meter was used to record current flow through the thermistor, which is proportional to temperature. This relationship was determined through calibration of the thermistor in a water bath of known temperature, using an accurate mercury thermometer.

The standard thickness minus lenses used in this study were Bausch and Lomb U4 (powers between -2.25 and 2.75D) and Silsoft (BC 8.30, OAD 12.5, -1.00D). Silsoft (+13.00D, OAD 12.5, BC 7.7 and 7.9) and Bausch and Lomb H4 (+12.50 and 13.00D) lenses were used in the high plus lens investigation. Temperature measurements were recorded upon stabilized readings in both open and closed eye conditions. A measurement was also attempted 5 seconds after the eye was opened, following a closed eye recording.

Six subjects were used in this study; five females and one male, all between the ages of 20 and 25. Of the six subjects, two had no previous contact lens exposure, three wore soft contacts, and one has adapted to hard lens wear. Standard statistical analysis was performed, at a 99% confidence level, to investigate our inter and intralens relationships.

RESULTS

Our results indicated no significant difference between cul-de-sac temperatures and the temperature with any of the study lenses, on the closed eye. However, there was a difference between cul-de-sac temperature and the recorded temperatures in both 5 second and stabilized open eye conditions, for all lenses. There was also a difference, in all cases, between the closed eye and both 5 second and stabilized open readings. Interestingly, only two of four lenses (B&L U4 and Silsoft plus) showed a significant difference between 5 second and stabilized open eye situations. Lastly, we found no significant difference between any study lenses in all three of the study conditions. The above results are depicted in chart #1.

Table #1 lists the mean temperature measurements and standard deviations of all subjects, for all study conditions. The temperatures were determined using the linear relationship between water bath temperature and current flow through the thermistor, as shown in graph #1 and its respective equation. The mean cul-de-sac temperature was 36.09°C ± 0.08°C, while the mean stabilized open eye temperatures varied from 34.03°C ± 0.46°C (B&L U4) to 34.60°C ± 0.30°C (Silsoft minus). The greatest variance was found with B&L H4 recording, while the least variance was noted with cul-de-sac temperature measurements.

DISCUSSION

The primary purpose of this study was to determine if a difference in corneal temperature exists under HEMA and silicon elastomer lenses. Secondarily, we used both high plus and standard thickness minus lenses to investigate the effect of lens thickness differences.

No significant difference was found between any of the study lenses in closed stabilized, open 5 second, and open stabilized conditions. Therefore, neither differences in heat conductivity between materials or lens thickness result is a statistically different corneal temperature. The largest difference found, although not significantly so, was between open stabilized recordings with B&L U4 and Silsoft minus lenses (34.03°C ± 0.46°C and 34.60°C ± 0.30°C respectively). Higher temperature readings underneath Silsoft lenses may be explained by decreased evaporation allowed with silicon material.

Even though our testing procedures actually measured tear film temperature between two contact lenses, our results compared well with other corneal temperature values reported in literature. The stabilized open findings varied from 34.03°C (B&L U4) to 34.60°C (Silsoft minus). Hill and Leighton[1], using a minimum clearance scleral lens and thermistor, found a corneal temperature of 31.3°C ± 1.59°C in relaxed open eyes. Mapstone[3], using a bolometer radiometric technique, found a mean corneal temperature of 34.8°C (33.2 to 36.0°C). A liquid-crystal contact lens device, used by Kinn and Tell[6], found corneal temperatures varying from 36.0°C to 35.0°C, with the apex cooler than limbally.

Rosenbluth and Fatt[5] believe the radiometric measurements of Mapstone's to be a truer estimation of corneal temperature than methods requiring direct corneal contact. A thermistor or thermocouple alone decreases temperature readings by increasing surface area for heat conduction and radiation while also measuring a temperature somewhere between that of air and the cornea. Contact lenses increase corneal temperature through insulation and decreased evaporation. Our results, therefore, should not be interpreted as actual corneal temperature, but by comparison of temperatures, underneath the study lenses, an investigation of inter and intra-lens relationships was performed.

Within our study, the least variance was found with cul-de-sac and closed stabilized recordings. A cul-de-sac mean temperature of 36.09°C ± 0.08°C was found, which is 0.91°C less than body temperature (37°C). The closed eye recordings, with all lenses, approached cul-de-sac temperature, with the minus lenses coming closer, though not statistically so. In open eye testing and especially with the high plus lenses, bubble formation and thermistor movement elicited a greater variance than found in closed eye testing.

Hill and Leighton[1] found stabilized corneal temperatures of 33.8°C ± 0.9°C for natural lid closure, while forced closure and blepharospasm elicited an average maximum of 35.1°C ± 0.8°C, which was statistically higher. Excessive obicularis muscle heat, above the effect of lid apposition alone, was believed to account for the net 3.8°C rise in corneal temperature with blepharospasm, as apposed to a net 2.5°C increase with natural closure. Our subjects were instructed to gently close their lids until a stabilized reading was obtained, with results ranging from 35.99°C ± 0.10°C to 35.90 C ± 0.17°C. As in open eye conditions, our results are higher than Hill and Leighton's, along with our net increases, ranging from 1.96°C (B&L U4) to 1.36°(Silsoft minus), which seems to indicate a greater heat dispersion with their scleral lens technique.

Hill and Leighton[1] also noted that although both cooling and warming times showed a rapid initial nonlinear change in temperature, the former was statistically slower. This temperature change is as predicted by Newton's Law of cooling or warming. Although time versus temperature change relationships were not specifically investigated, we did note rapid initial temperature changes . . .

followed by a more gradual shift towards stabilization.

We expected a significant difference in temperature between open and closed eye conditions, as was found with all study lenses. However, the lack of statistical temperature differences between all lenses in all study conditions was significant. It indicates that little difference in corneal temperature should be expected with the use of standard thickness minus and high plus lenses made of either HEMA or silicon elastomer materials.

CONCLUSION

This study was designed to investigate the effect of different contact lens materials and thicknesses on the resultant corneal temperature. The results of this study are:

1. No difference in temperature was found in closed stabilized, open 5 seconds, and open stabilized conditions between standard thickness minus and high plus HEMA and silicon elastomer lenses.

2. A significant difference in temperature exists between closed and open eye conditions, under all study lenses.

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Comparison of Test Conditions

Chart # 1

	Cul-de-sac	U4 closed	U4 5 sec.	U4 stab.	H4 closed	H4 5 sec.	H4 stab.	Sil(-) closed	Sil(-) 5 sec.	Sil(-) stab.	Sil(+) closed	Sil(+) 5 sec.	Sil(+) stab.
Cul-de-sac	-	E	Δ	Δ	E	Δ	Δ	E	Δ	Δ	E	Δ	Δ
U4 closed		-	Δ	Δ	E	-	-	E	-	-	E	-	-
U4 5 sec.			-	Δ	-	E	-	-	E	-	-	E	-
U4 stab.				-	-	-	E	-	-	E	-	-	E
H4 closed					-	Δ	Δ	-	-	-	E	-	-
H4 5 sec						-	E	-	E	-	-	E	-
H4 stab.							-	-	-	E	-	-	E
Sil(-) closed								-	Δ	Δ	E	-	-
Sil(-) 5 sec.									-	E	-	E	-
Sil(-) stab.										-	-	-	E
Sil(+) closed											-	Δ	Δ
Sil(+) 5 sec.												-	Δ
Sil(+) stab.													-

Test of Significance @ 99% Confidence Level

Δ - significantly different @ 99% level

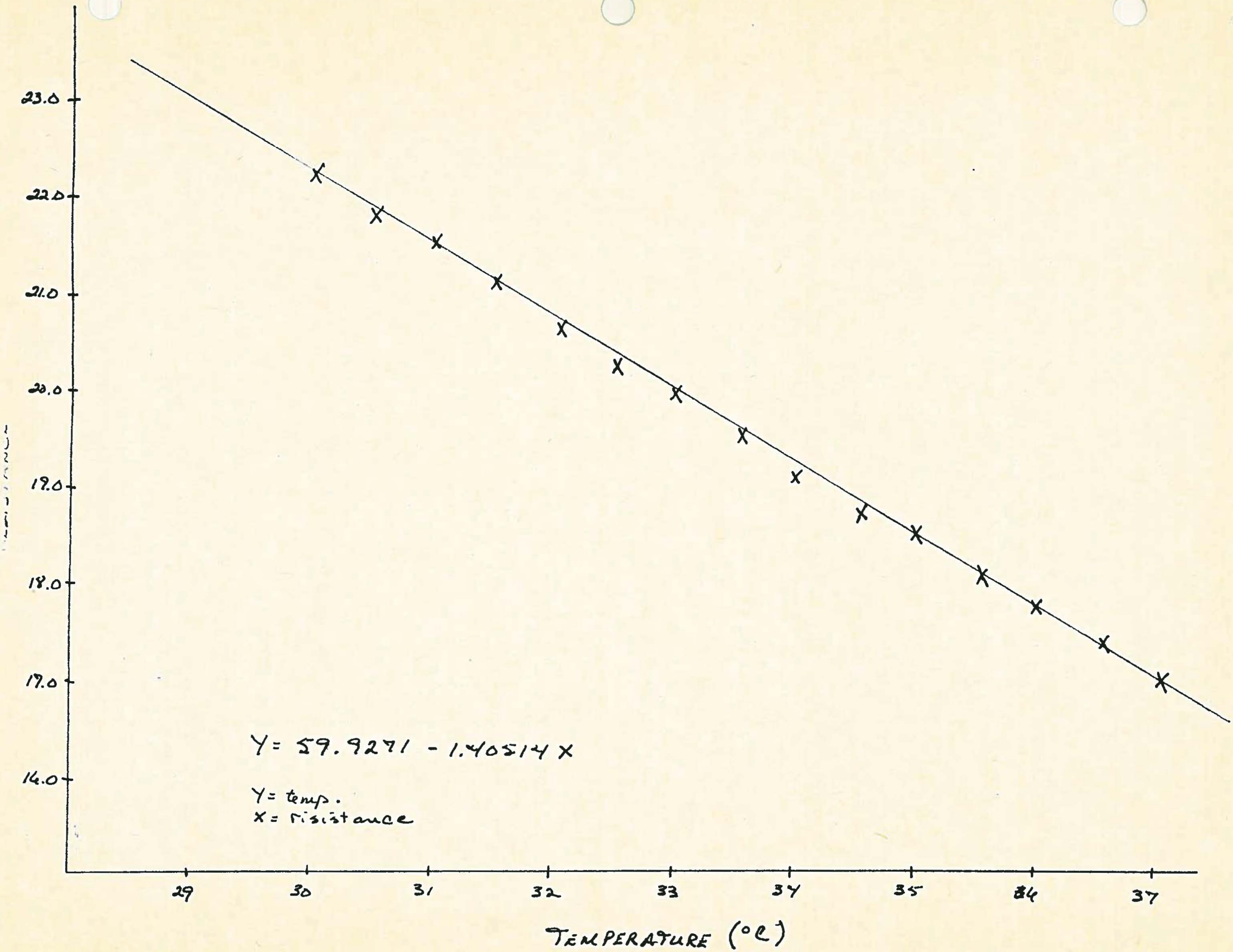
E - equal @ 99% level

\- not performed

MEANS OF ALL PATIENTS

	Subject#	Mean(°C)	Standard Deviation(°C)
cul-de-sac	6	36.09	0.08
U4 closed	6	35.99	0.10
U4 5sec.	6	34.81	0.25
U4 stabil.	6	34.03	0.46
H4 closed	6	35.90	0.17
H4 5sec.	6	35.09	0.35
H4 stabil.	6	34.29	0.56
Silsoft - closed	6	35.96	0.27
Silsoft - 5sec.	5	35.10	0.20
Silsoft - stabil.	6	34.60	0.30
Silsoft + closed	6	35.90	0.16
Silsoft + 5sec.	5	35.13	0.19
Silsoft + stabil.	6	34.41	0.25

Graph #1



23.0
22.0
21.0
20.0
19.0
18.0
17.0
14.0
Y= 59.9271 - 1.40514 X
Y= temp.
X= risistance
29
30
31
32
33
34
35
36
37
TEMPERATURE (°C)

REFERENCES

1. Hill, R.M. and A.J. Leighton, "Temperature Changes of Human Cornea and Tears Under a Contact Lens: I, Am. J. Optom. 42: 916, 1965.
2. Hill, R.M. and A. J. Leighton, "Temperature Changes of Human Cornea and Tears Under a Contact Lens: II, Am. J. Optom. 42: 72-77, 1965.
3. Mapstone, R., "Normal Thermal Patterns in Carneal and Peri-orbital Skin", Brit. J. Ophth. 52: 818, 1968.
4. Mikesell, G.W., "Corneal Temperatures - A Study of Normal and Laser Injured Corneas in the Dutch Belted Rabbit", Am. J. Optom. 55: 2; 108-115, 1978.
5. Rosenbluth, R.F. and I. Fatt, "Temperature Measurements in the Eye", Exp. Eye Res. 25: 325-341, 1977.
6. Kinn, J.B. and R.A. Tell, "A Liquid-Crystal Contact-Lens Device for Measurement of Corneal Temperature", IEEE 20: 387-388, 1973.