Temperature Effect of Silicone Oil at the Anterior Segment

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ABSTRACT

Purpose: To evaluate the effect of silicone oil tamponade on the central corneal temperature using noncontact infrared thermometer (NCIT) in vitrectomized eyes.

Methods: Sixty eyes of 60 patients who underwent pars plana vitrectomy and intraocular silicone oil tamponade were enrolled in this prospective study. Central corneal temperatures were measured by handheld NCIT from the corneal surface and these values were compared with the corneal temperatures of the contralateral eyes of the same subjects.

Results: Statistically significant difference was observed between silicone oil filled eye and contralateral nonoperated eye ($p<0.001$). There was a significant correlation between temperature of silicone oil filled eye and contralateral eye ($p<0.001$). Statistically significant negative correlation was observed between postoperative period and temperature of silicone oil filled eye ($p=0.003$). The mean values of temperatures were found to be higher statistically in phakic eyes compared with pseudophakic ones in both silicone oil filled and contralateral eye group ($p=0.010$, $p=0.011$, respectively).

Conclusion: Silicon oil and acrylic and polymethylmethacrylate lenses may affect tissue metabolism because it changes heat conduction. Heat change in tissues can be responsible for complications. Further studies are needed to confirm our results.

Keywords: Corneal temperature, Infrared thermometer, Eyes with silicone oil.

INTRODUCTION

Silicone oil (SO) is a tamponade that is frequently used in complicated vitreoretinal cases, such as giant tear retinal detachment, proliferative vitreoretinopathy, trauma, and endophthalmitis.[1] In some cases, SO cannot be removed early, and it remains in the eye for a long time.[2,3] Development of cataracts, glaucoma, band keratopathy, late corneal decompensation, hypotony, and iritis has been reported due to the long-standing presence of SO in eyes.[1, 4-7] It is not known whether these complications are associated with temperature changes in these eyes, which could be due to the presence of SO. It is also unknown if intravitreal SO affects the temperature of the globe.

Noncontact infrared thermometer (NCIT) measures electromagnetic rays that naturally radiates from the body and are related with body temperature.[8] Handheld NCIT has been used world wide in routine general health practice with the advantage of being cheap and easy to use. The accuracy was reported in many studies.[9-11] A high lineer correlation between right and left eye corneal temperature measurements with both NCIT and infrared video-thermometry in healthy eyes was reported previously in literature.[12]

The present study aimed to be the first to attempt to answer the question: Does intravitreal SO affect the temperature of the globe? Thus, we measured the temperature difference between eyes with and without SO tamponade using a handheld, noncontact infrared thermometer (NCIT).

METHODS

This prospective study consisted of patients with intraocular SO tamponade who underwent pars plana vitrectomy for repair at Istanbul Education and Research Hospital, Department of Ophthalmology, Retina Clinic, between December 2015 and May 2016. Written informed consent was obtained from each patient following a detailed explanation of the objectives and protocol of the study, which was conducted in accordance with the ethical

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principles stated in the Declaration of Helsinki; the study was approved by the institutional ethics committee.

In each patient, the corneal temperature was measured in the eye filled with SO and the healthy fellow eye of the same subject. The body temperature of the subjects was also obtained. In all patients, the central corneal temperatures were measured, as previously described, using NCIT, a handheld infrared skin thermometer (MEDISANA, FTN, Hilden, Germany) from the corneal surface[12] under the same environmental conditions, including fixed room temperature, humidity, and illumination (25°C; humidity range of 45%–55%). The aiming beam of the handheld infrared skin thermometer was centered slightly inferotemporally to the center of the cornea. The working distance was defined as the distance where the aiming beam formed sharp concentric rings on the iris. Three measurements were taken from each eye, and the mean value for each eye was used for analysis (Figure 1). This device measures temperatures ranging from 16ºC to 40ºC, with a minimum accuracy of 0.2ºC. Measurements can be obtained for each patient in less than one second.

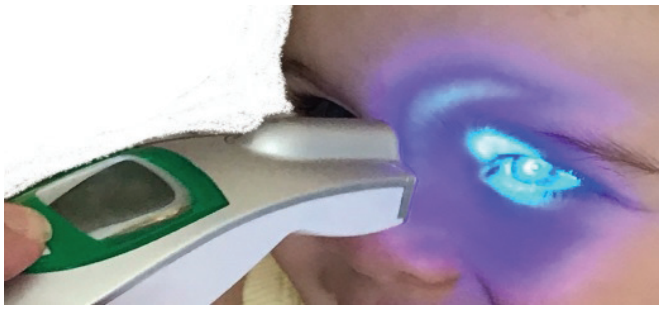

Figure 1. *Central corneal temperatures were measured by handheld NCIT from the corneal surface.*

Prior to any temperature measurements, all patients underwent a thorough ophthalmic examination, including a best corrected visual acuity assessment, slit-lamp biomicroscopy, dilated fundus examination, and intraocular pressure measurement using Goldmann applanation tonometry. A detailed medical history was obtained from each patient. Age, gender, and the presence of any systemic diseases were recorded for each patient. The interval between surgery and the date of the temperature measurement was noted. To avoid inter-observer variations, all temperature measurements were done by a single examiner (EU).

Patients were excluded from this study if they had ever undergone eye surgery (except for pars plana vitrectomy, cataract surgery, and primer suturing), such as refractive surgery, glaucoma surgery, SO used in surgery, except for 1000 centistoke silicone, cases with intraoperative and/or postoperative complications, and recurrent cases of retinal detachment. Moreover, patients who had active ocular or periocular infections and systemic infective illnesses were excluded.

The statistical analysis was performed using SPSS software for Windows version 15.0 (SPSS Inc., Chicago, Illinois, USA). Because the normality of the data was not accomplished, the Mann-Whitney U test was used to compare the independent groups. In the dependent groups, repeated measures variance analysis was used because normality of the data was accomplished. A 95% confidence interval and $p<0.05$ was accepted as statistically significant.

RESULTS

The demographic data is presented in Table 1. The mean values of the temperature of the SO-filled eye, the contralateral eye, and body temperature are shown in Table 2.

The temperature was significantly higher in the eyes with SO tamponade than the contralateral non-operated eyes; the temperature in the SO-filled eyes was also higher than the body temperature ($p<0.001$) (Table 2). A statistically significant negative correlation was observed between the postoperative period and the temperature of the SO-filled eye ($p=0.003$) (Table 3). There was a significant correlation between the temperature of the SO-filled eye and the contralateral eye ($p<0.001$) (Table 3). The mean

Table 1.*Demographic and clinical characteristics of the all groups.*	
Mean age±SD (Range, year)	61.56±13.29 (36-88)
Male / Female, (n)	38/22
Eyes with silicone oil tamponade, (right/left), (n)	24/36
Eyes with silicone oil tamponade (Phakic eyes/ Pseudophakic eyes), (n)	10/50
Eyes without silicone oil tamponade, (Phakic eyes/ Pseudophakic eyes), (n)	26/34
Mean postoperative time, (day)	135.73±238.88 (1-990)
Diagnosis (RD/DRP/RVO/PET) (n)	44/12/2/2
RD: Retinal detachment, **DRP**: Diabetic retinopathy, **RVO**: Retinal vein occlusion, **PET**: Perforating eye trauma, **SD**: standard deviation	

Table 2. *Comparision of eye temperature with and without silicone oil tamponade (ºC).*		
	Mean.±SD, Min-Maks	**p**
Eyes temperature with silicone oil tamponade	37.01±0.48, (35.5-37.9)	p<0,001
Eyes temperature without silicone oil tamponade	36.99±0.39, 35.80-37.60	

Table 3. *Correlation between post-operative time and eyes temperature with and without silicone oil tamponade.*				
	Post-Operative Time		**Eyes temperature with silicone oil tamponade**	
	rho	p[W]	rho	p[W]
Eyes temperature with silicone oil tamponade	-0,379	0,003		
Eyes temperature without silicone oil tamponade	-0,189	0,147	0,806	<0,001
[W] Spearman Correlation Analysis				

values of the temperatures were statistically higher in the phakic eyes in comparison to the pseudophakic eyes in both the SO-filled group and the contralateral eye group (p=0.010, p=0.011, respectively) (Table 4). Additionally, in the univariate analysis, the patient's age, sex, and diagnosis were not related to the temperature of the eye (p=0.281, p=0.358, and p=0.824, respectively).

DISCUSSION

A handheld NCIT is commonly used to measure body temperature in routine general health practice, worldwide. Many studies have been conducted to analyze its accuracyb[13-15]

Corneal temperature measurements have evolved in accordance with developments in body temperature measurement techniques. After the first report by Mapstone[16] concerning the use of an infrared thermometer, that instrument has been widely used for this purpose.

Oztas et al.[12] conducted a study investigating the correlation between corneal temperature measurements using NCIT and infrared video thermometry in healthy individuals; that study reported a highly significant linear correlation between the measurements obtained by the two devices. Moreover, the authors found a moderate correlation between a handheld NCIT and video thermometry regarding corneal temperature measurement.[12] They concluded that a handheld NCIT can be used as a screening test to measure corneal temperature.

Tissue temperature is one of the baseline characteristics of tissue metabolism, and it can play a pivotal role in understanding ocular physiology.[13] Several studies have reported corneal temperature measurements in the assessment of tear film abnormalities, ocular inflammation blood flow, bleb function after glaucoma filtering surgery, and photorefractive surgery.[16-24]

Tissue temperature is affected both by tissue metabolism and tissue blood flow.[25,26] Retina is one of the tissues which has high metabolic activity rate in accordance with weight and fed by the choroid, the tissue with the most intense blood flow rate in the body.[27, 28] So the temperature of the anterior segment of the eye is expected to be affected from the surrounding tissues as well as from the radiating heat sourcing from the posterior segment of the eye such as retina and choroid. The heat spreading from the posterior segment, radiates through vitreous in non-vitrectomized eyes and through silicone oil in vitrectomized eyes. In phakic eyes, heat radiates through crystalline lens whereas but in pseudophakic eyes heat passes from acrylic or polymethylmethacrylate lenses. The measured temperature is also affected by the tissues capability of heat conductivity. Table 5 represents the thermal

Table 4. *Comparison of phakic and pseudophakic groups temperatures in eyes with and without silicone oil tamponade.*			
	Mean.±SD (median)		
	Phakic eyes	**Pseudophakic eyes**	**p**
Eyes with silicone oil tamponade	37,3±0,4 (37.3)	36,9±0,5 (37)	0,010
Eyes without silicone oil tamponade	37,1±0,5 (37.3)	36,9±0,3 (37)	0,011

Table 5. *Thermal Conductivity of Materials/Substances at 25°C temperature.*	
Material/Substance	**Thermal Conductivity - k - W/(m K)**
Water	0.58
Silicon oil	0.1
Acrylic	0.2
Polymethylmethacrylate	0.17 - 0.25

conductivity of materials such as water, silicone oil and intraocular lenses at 25ºC. Silicone oil was found to have about 5 times less heat conductive capacity in comparison to water. Biochemical analysis discloses that about 99% of the vitreous is water; about 1% is composed of inorganic salts and organic lipids of low molecular weight, and about 0.1% consists of proteins and hyaluronic acid. With age syneresis occurs, the collagen framework collapses and the hyaluronic acid concentration decreases. One may assume that the conductivity of vitreous becomes nearly similar with water with increasing age.[29]

In the early postoperative period there is generally increased ocular inflammation, and increased inflammation increases heat production due to increased metabolic activity and blood flow. In our study, we could not observe any significant temperature difference between silicone oil filled eye and contralateral eye. Also we could not observe any difference between two eyes inspite of inflammation in the early postoperative periods, this is may be due to the low conductivity of silicone oil comparing vitreous/water. So we could have underestimate the temperature change in the early postoperative periods because of silicone oil conductivity.

Also we observed that there is a statistically significant negative correlation between postoperative period and temperature of silicone oil filled eye. This means that with time as the early postoperative inflammation decreases, the metabolic activity and blood flow rate decreases and temperature decreases. In warm environment as occurs in the early postoperative period, mineral compounds find in molted state and as the temperature decreases with time in silicone filled eyes these compounds can make sediments. These sediments precipitates with gravity in perisilicone fluid and alter the metabolic activity of both crystalline lens and corneal endothelium. The decrease in temperature can contribute on development of these complications.

In this study we also observed that in pseudophakic eyes temperatures are lower in comparison to phakic eyes in both silicone oil filled and contralateral eye groups. This can be due to the less thermal conductivity of acrylic and polymethylmethacrylate lenses according to the crystalline lens so the heat from the posterior segment of eye is less conducted to the anterior segment.

There are some limitations of the study including small number of patients, having a heterogeneous study population, and not comparing the results with different thermometer device such as infrared videothermometry. Additionally, because we exclude the patients treated with silicone oil other than 1000 centistoke silicone, and the patients with intraoperative and / or postoperative complications, we could not evaluate the relationship. between temperature alteration and complications

CONCLUSION

We measured the temperature of SO-filled eyes to determine if its presence is associated with the development of eye complications, such as cataracts, glaucoma, band keratopathy, late corneal decompensation, hypotony, and iritis. However, several questions remain. Is the temperature in these eyes low due to the low thermal conductivity of SO? Does SO affect the metabolism of the eye tissue and change the temperature of the tissue? Can a minimal change in the temperature have an effect on future, long-term complications? These questions could be answered by future randomized controlled studies.

Our study was the first to investigate the thermal conductivity of SO in eyes. Thus, our work is valuable in this respect. In order to address all the issues related to SO in eye tissue, more prospective controlled studies should be performed.

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