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Bacterial populations on silicone hydrogel and hydrogel contact lenses after swimming in a chlorinated pool

Abstract

Purpose: A number of reports have indicated an association between swimming with contact lenses and subsequent eye infection. This study tests whether a hydrophilic contact lens worn while swimming accumulates bacteria present in the water. It was of interest to determine if lens type (silicone hydrogel versus hydrogel) affected the result.

Methods: Fifteen healthy non-contact lens wearers swam for 30 minutes with a silicone hydrogel lens (Purevision) on one eye and a hydrogel lens (Acuvue 2) on the other. Lenses were removed aseptically and placed in sterile vials five minutes after the subjects left the water. Microbial growth was enumerated for total numbers of colonies and categorized by species present. Numbers of colonies were compared between the two lens groups, and with a water sample taken from the pool at the time of the experiment. Eight of the subjects returned on a different day and wore new lenses for thirty minutes under normal room conditions.

Results: Two lenses were lost while swimming. 27 of the remaining 28 lenses worn while swimming showed colonization, principally with *Staphylococcus epidermidis*, which was also by far the most common species identified from the water itself. Small numbers of *Staphylococcus aureus* and *Streptococcus salivarius* were also present in both the water and on the lenses. Numbers of colonies varied among subjects (range 0-230), but no differences were observed between the two lens groups. Lenses removed after thirty minutes of wear without swimming were mostly sterile, with 3 of the 16 lenses showing just two colonies each.

Conclusion: It appears that wearing a hydrophilic lens while swimming allows accumulation of microbial organisms on, or in, the lens, regardless of lens material. Swimmers should be advised to wear tight fitting goggles if lenses are worn while swimming, and thorough disinfection of the lenses prior to overnight wear seems prudent.

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**BACTERIAL POPULATIONS ON SILICONE
HYDROGEL AND HYDROGEL CONTACT LENSES
AFTER SWIMMING IN A CHLORINATED POOL**

By

**JENNIFER D. CHOO
KATHY N. VUU**

A thesis submitted to the faculty of the
College of Optometry
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for the degree of
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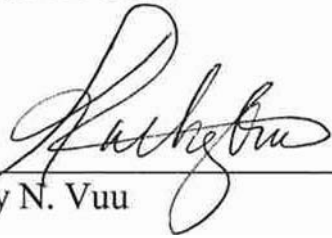
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Bacterial Populations on Silicone Hydrogel and Hydrogel Contact Lenses **After** Swimming in a Chlorinated Pool

Authors:



Jennifer D. Choo



Kathy N. Vuu

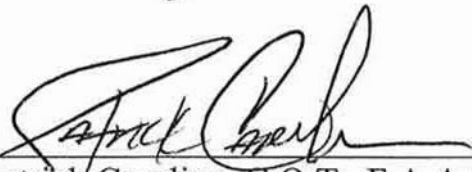
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Biography

Jennifer Choo was born and raised in Vancouver, British Columbia, Canada. She graduated from the University of British Columbia with a Bachelor's of Science degree in Cell Biology and Genetics, Upon graduation in May 2004, she intends to pursue a Ph. D combining her optometric knowledge, interest in contact lenses and her background in cell biology and genetics.

Kathy Vuu was born in Vietnam and came to the U.S. in 1980 where she settled in Lynnwood, Washington. She attended the University of Washington and graduated from there with a BS degree in Speech and Hearing Sciences. She hopes to practice in the Seattle area after graduation, but is open to challenges elsewhere.

Abstract

Purpose: A number of reports have indicated an association between swimming with contact lenses and subsequent eye infection. This study tests whether a hydrophilic contact lens worn while swimming accumulates bacteria present in the water. It was of interest to determine if lens type (silicone hydrogel versus hydrogel) affected the result.

Methods: Fifteen healthy non-contact lens wearers swam for 30 minutes with a silicone hydrogel lens (PureVision) on one eye and a hydrogel lens (Acuvue 2) on the other. Lenses were removed aseptically and placed in sterile vials five minutes after the subjects left the water. Microbial growth was enumerated for total numbers of colonies and categorized by species present. Numbers of colonies were compared between the two lens groups, and with a water sample taken from the pool at the time of the experiment. Eight of the subjects returned on a different day and wore new lenses for thirty minutes under normal room conditions.

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Conclusion: It appears that wearing a hydrophilic lens while swimming allows accumulation of microbial organisms on, or in, the lens, regardless of lens material. Swimmers should be advised to wear tight fitting goggles if lenses are worn while swimming, and thorough disinfection of the lenses prior to overnight wear seems prudent.

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We would like to thank Ocular Sciences for financial support of this work through their Contact Lens Research Grant Program.

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INTRODUCTION

Contact lenses are widely accepted as a means to safely and effectively correct refractive errors. Questions remain however, with respect to the safety and efficacy of contact lens wear during water activities. [1] [2] [3].

The FDA and many contact lens manufacturers do not endorse the use of contact lens wear during water activities because of the perceived increased risk of ocular infections. The benefits of contact lens wear during water activities, however, may outweigh the risks for some patients. Factors such as improved vision, increased safety, and corneal protection must be considered. In a study done by Solomon, subjects who wore soft contact lenses while swimming showed significantly less corneal staining than those who swam without lenses. [4] This suggests a protective role for contact lenses against the toxicity of swimming pool water.

The perceived risk of ocular infections associated with contact lens wear is generally based on the notion that contact lenses tend to accumulate bacteria. Callender et al compared the microflora of the eye of hydrogel contact lens wearers with that of nonwearers. [5] They found an increase in the bacterial population in contact lens wearers but not a significant change in the variety of organisms present. Furthermore, Keay et al found that the 30 night extended wear silicone hydrogel lenses are colonized by similar numbers and types of bacteria compared to HEMA-based lenses. [6]

Numerous research and clinical cases have shown the association between bacterially contaminated contact lenses and the development of ocular complications, the most serious of which is microbial keratitis. Anecdotal reports indicate a high association of incidence of microbial keratitis with swimming in lenses. Risk of acanthamoeba infection has also been highly associated with swimming with soft contact lenses. [7] [8]

With the approval of high Dk/t silicone hydrogels for 30 day extended wear, practitioners are faced with the dilemma of how to counsel their contact lens patients who participate in water activities. Is it alright for lenses to be worn? Do lenses need to be disinfected after swimming? Can the lenses be slept in? Currently there is very little data on bacterial populations present on contact lenses after water activities to help answer these questions. The purpose of this study was to investigate the hypothesis that a hydrophilic contact lens worn while swimming accumulated bacteria present in the water. In addition, the affect of lens type (silicone hydrogel versus hydrogel) on the number or kind of bacteria accumulated was investigated.

MATERIALS AND METHODS

This study was performed in two parts.

Lenses: The lenses used in this study were etafilcon A (low Dk/t= 26×10^{-9} [cm x mL O₂][s x mL x mmHg]⁻¹, 58% water content, anionic polymer (Vistakon Inc.) and balafilcon A (high Dk/t= 110×10^{-9} [cm x mL O₂][s x mL x mmHg]⁻¹, 36% water content, fluorosilicone hydrogel polymer (Bausch & Lomb).

Subjects: 15 subjects, 8 male and 7 female, were recruited to wear a balafilcon A lens on one eye and an etafilcon A lens on the other eye while swimming. The subjects were all non-contact lens wearers. In order to establish a baseline of non-swimming conditions, 8 of the original 15 subjects returned and wore the same parameter lenses on the same eyes under normal room conditions.

The Institutional Review Board of Pacific University approved the experimental protocols. Subjects signed a record of informed consent. All subjects were examined with a biomicroscope by an optometrist and were found to be free of ocular disease.

Study Design: Each of the lens types (etafilcon A and balafilcon A) were randomly assigned to an eye of the subjects and were worn simultaneously. The 15 subjects wore the lenses for a total of 50 minutes. After a 10 minute equilibration period, subjects were instructed to participate in a variety of pool activities (swimming, diving, and retrieving objects from the pool) for 30 minutes. After 10 minutes of equilibration time out of the water the lenses were removed aseptically and placed into sterile vials.

In order to establish a comparison baseline, 8 subjects returned on another day and wore identical lenses on the same eyes. Subjects were instructed to wear the lenses for a total of 50 minutes while performing some of their daily activities (reading, conversing). Lenses were removed via the same sterile procedures as in part one after the prescribed wearing time and placed into sterile vials. Lenses were removed as close to the end of the prescribed period of wear as possible.

For both parts of the study, full anterior eye examinations using a biomicroscope were conducted before the lenses were inserted and after the lenses were removed. An Optometrist was readily available and emergency protocols were in place if a subject were to have an adverse response during the course of the study.

Microbiological analysis: Lenses were aseptically removed from each eye and placed into a sterile tube containing 1.5 ml of phosphate buffered saline (PBS) (pH 7.1). Each tube was immediately vortexed for 30 seconds. The PBS solution was aseptically removed from the tube and plated on a chocolate agar plate. Plates were incubated at 35°C for 24 hours.

Plates were examined for numbers of distinct colony types based on colony color and morphology. Representative colonies of each type were aseptically transferred to chocolate agar and nutrient agar plates. The chocolate agar plates were used to maintain cultures however the dark agar made it difficult to examine morphological characters. Nutrient agar plates were used to examine colony pigment and morphological characteristics.

Representative colonies were Gram stained and identified using differential plating media and standard microbiological biochemical testing. Biochemical tests for the presence of the enzyme catalase were performed to differentiate between genera.

Staphylococcus species were differentiated using blood agar and mannitol salt agar. *Streptococcus* species were differentiated using blood agar and agar containing 5% sucrose.

Statistical analysis: Paired t-tests were used to test for differences in the proportions of total colonies and individual colonies from baseline. Unpaired t-tests were used to test for differences in variable between the 2 lens types.

RESULTS

Of the various types of bacteria found in the ocular environment, only 3 were found to colonize the lenses: *Staphylococcus epidermidis*, *Staphylococcus aureus* and *Staphylococcus salivarius*. *S. epidermidis* had the greatest proportion of samples colonized in both the Etafilcon A (Acuvue) and Balafilcon A (Purevision) lenses. The bacterial load (median) for the Acuvue and Purevision lenses were 60 cfu/lens and 72 cfu/lens respectively. However, the median number of cfu/lens for *S. aureus* and *S. salivarius* were <1 cfu/lens. There was a significant difference between the swimming and the baseline conditions for total bacterial colonies and *S. epidermidis* ($p < 0.001$). No difference was found for *S. aureus* or *S. salivarius*. The R and L eye lenses were found to have similar results. No differences in any variables were found between the lens types, for either the R or L eye.

Table 1 displays the total colonies detected for each "swimming" eye.

Subject	Number of total colonies		Lens Worn	
	Right eye	Left eye	Right eye	Left eye
1	0	1	A	P
2	204	9	A	P
3	230	58	P	A
4	221	165	A	P
5	31	15	P	A
6	37	75	A	P
7	77	88	P	A
8	9	lost	A	P
9	64	lost	A	P
10	28	107	P	A
11	86	78	A	P
12	187	132	P	A
13	92	63	P	A
14	10	55	A	P
15	87	18	P	A

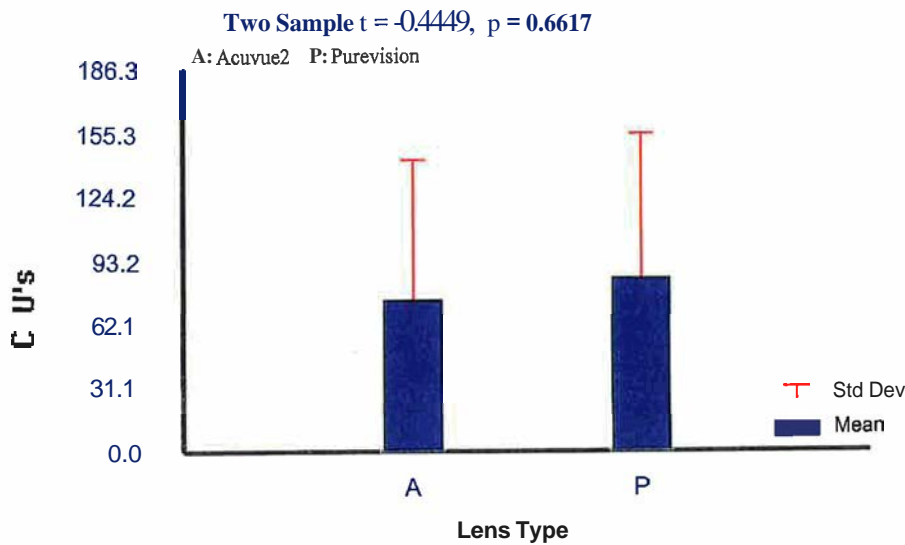
Table 1: Total number of colony forming units from lens worn while swimming. Lens A = Acuvue 2, P lens = Purevision.

Representative statistics are presented here. A 2 sample paired t- test was used to show significance in difference between the "swim" and "non-swim" lenses:

Group:	Swim Lenses	Non-swim lenses
Size:	28	16
Mean:	79.5457	0.375
SD:	67.9022	0.8062

t-value: 4.3937
 2 tail Probability: 0.0006
 eta squared: 0.5796

Unpaired t-test was performed to test for difference in lens types. There does not appear to be any difference between the two lens types.



2 sample t-test: CFU's by lens type for all "swim" lenses

Subset:	Acuvue	Purevision
Size:	15	13
Mean:	74.1333	85.7692
SD:	68.4323	69.5128

F-Ratio (Var): 1.0318
 DF: 12, 14
 2-Tail Prob: 0.9676

t-Value: -0.4449
 DF: 27.305
 2-Tail Prob: 0.6617

Omega Squared: -0.0295
 Eta Squared: 0.0072

DISCUSSION

This paper describes the bacterial populations found on silicone hydrogel and hydrogel contact lenses after swimming in a chlorinated pool. We found that swimming with contact lenses results in an increase in microorganisms present on (or in) the lenses, regardless of lens type, in comparison to lenses worn in a normal room environment for the same length of time.

Our baseline study detected few microorganisms on the lenses after 50 minutes of normal wear. Only 3 of the 16 lenses isolated showed any bacterial growth, having only 2 colonies per lens. All but one of the lenses was removed aseptically from the eye, this contaminated lens revealed only 2 bacterial colonies. Other studies have also found low microorganism contamination of lenses while on the eye.[9] The only microorganism isolated in our baseline study was *S. epidermidis*, a common bacterium present in the flora of the eye. [10]

When the contact lenses were worn while swimming, the total number of colonies isolated increased dramatically, up to a high of 230 colonies. While 2 of the lenses were lost while swimming, 27 of the 28 remaining lenses showed bacterial colonization. The predominant species isolated was *S. epidermidis*, which was also by far the most common species identified from the water itself. Small numbers of *S. aureus* and *S. salivarius* were also present in both the water and on the lenses. While the colonization of these lenses were by microorganisms that are part of the normal ocular microbiota which in small amounts are considered non-pathogenic, it is known that in large amounts they increase the risk of corneal complications. [6]

In order to limit potential risk to the subjects, this study was limited to a chlorinated pool, an environment in which many microorganisms are eliminated with careful monitoring of chlorine and pH levels. Despite this careful monitoring, some microorganisms are present in the water. The microbes identified from the water were the same as those found on the lenses worn while swimming. Other bodies of water such as lakes, beaches or rivers may be expected to contain significantly greater amounts and varieties of bacteria which are potentially pathogenic to the eye. Thus, it is assumed that engaging in outdoor water activities while wearing contact lenses may increase the risk of ocular infections. Microbial keratitis, the most severe sight threatening contact lens complication, has frequently been reported in patients who have swum in their extended wear lenses within weeks of their presentation. Furthermore, it has been found that the risk of contamination of extended wear contact lenses increases with lens age [9]. The lenses we used were all new lenses in sterile packaging and were worn for less than one hour.

It was also of interest in the study to determine if lens type (silicone hydrogel versus hydrogel) had any affect on the number or kind of bacteria accumulated. Numbers of colonies varied among subjects (0-230), but no significant differences in types of bacteria isolated were observed between the two lens types, for either the right or left eye. In support of our findings, Keay et al also found that the number and type of bacteria isolated from silicone hydrogel lenses were no different than hydrogel lenses. Therefore, it is not the lens

type that is a great factor in bacterial accumulation on the lenses, but rather the environment that increases the chances for microbial binding.

CONCLUSION

It appears clear that swimming with contact lenses "loads" the contact lens with the same microorganisms present in the water. It is likely that normal tear flow and antimicrobial tear factors help to decrease the chance that the microbes will colonize to the point there is risk of infection. We only allowed our subjects to wear the lenses for ten minutes after exiting the water. One might expect we would have found significantly lower microbial loads on the lenses had we allowed the subjects to wear the lenses the remainder of the day. Such procedure may unduly put subjects at risk, however.

Based on our findings, swimmers should be advised to wear tight fitting goggles if lenses are worn while swimming. Overnight wear following swimming with lenses is ill-advised. Thorough disinfection of the lenses prior to resumption of overnight wear seems prudent.

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