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LABORATORY STUDY

Contact lens disinfecting solutions antibacterial efficacy: comparison between clinical isolates and the standard ISO ATCC strains of *Pseudomonas aeruginosa* and *Staphylococcus aureus*

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Abstract

Purpose **To evaluate the disinfectant properties of the three multipurpose contact lens disinfecting solutions available in Iran, against clinical isolates and the standard ISO ATCC strains of *Pseudomonas aeruginosa* and *Staphylococcus aureus*, based on the international organization for standardization (ISO) 14729 guidelines.**

Methods **Three multipurpose solutions that were tested were ReNu Multiplus, Solo Care Aqua and All-Clean Soft. The test solutions were challenged with clinical isolates and the standard strains of *P. aeruginosa* (ATCC 9027) and *S. aureus* (ATCC 6538), based on the ISO Stand-alone procedure for disinfecting products. Solutions were sampled for surviving microorganisms at manufacturer's minimum recommended disinfection time. The number of viable organisms was determined and log reductions calculated.**

Results **All of the three test solutions in this study provided a reduction greater than the required mean 3.0 logarithmic reduction against the recommended standard ATCC strains of *P. aeruginosa* and *S. aureus*. Antibacterial effectiveness of Solo Care Aqua and All-Clean Soft against clinical isolates of *P. aeruginosa* and *S. aureus* were acceptable based on ISO 14729 Stand-alone test. ReNu MultiPlus showed a minimum acceptable efficacy against the clinical isolate of *S. aureus*, but did not reduce the clinical isolate by the same amount.**

Conclusions **Although the contact lens disinfecting solutions meet/exceed the ISO 14729 Stand-alone primary acceptance criteria for standard strains of *P. aeruginosa* and *S. aureus*, their efficacy may be insufficient against clinical isolates of these organisms.**
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Keywords: contact lens solutions; disinfectant efficacy; *pseudomonas aeruginosa*; *staphylococcus aureus*

Introduction

Worldwide, millions of people use contact lenses as an alternative to spectacles. It has been shown contact lenses wear, especially extended wear, is a major risk factor for microbial keratitis and corneal ulcers.[1–5] Although the incidence rates of contact lens-related microbial keratitis is very low, this complication is an important health concern because a very large population is at risk and because of the potential for poor visual outcome and blindness.[6,7]

Investigations have documented that contact lens-related microbial keratitis is most commonly caused by bacteria, such as Pseudomonas aeruginosa and Staphylococcus aureus.[8–15]

P. aeruginosa is a Gram-negative bacterium that is commonly found in many environments, including water. It is an opportunistic pathogen and innately resistant to dilute solutions of disinfectants. Also *P. aeruginosa* keratitis associated with contact lens wear is difficult to treat because *P. aeruginosa* can display multiple resistance to antibiotics.[16–18] Studies showed that extended wear of soft contact lenses increases the adherence of *P. aeruginosa* to the epithelial cells of its wearers.[19,20]

S. aureus is an aerobic Gram-positive bacterium carried by 50–60% of normal population on the hands, face, nose, and skin as a commensal bacterium, and can readily find access to the eye. Generally, Staphylococcal ocular infection is most likely due to hand-to-eye transfer. One study showed that *S. aureus* is the most common bacterial cause of contact-lens-induced peripheral ulceration.[13]

The goal of this laboratory-based study is to evaluate and compare the antibacterial activity of the three multipurpose contact lens disinfecting solutions available in Iran when inoculated with the clinical isolates and standard ATCC strains of *P. aeruginosa* and *S. aureus*, based on the ISO 14729 Stand-alone procedure for disinfecting products.

The ISO 14729 guidelines are the used standard in industry to demonstrate the activities of contact lens disinfecting solutions against microorganisms. According to this guidelines for Stand-alone primary criteria, an active contact lens disinfecting solution must be able to reduce the viability of starting concentration of bacterial species (*S. aureus*, *Serratia marcescens*, *P. aeruginosa*) by 3 log (99.9%) and fungal species (*Fusarium solani* and *Candida albicans*) by 1 log (90%) at minimum disinfecting time as specified according to the manufacturer's label.[21–22]

Materials and methods

Test solutions

Three multipurpose lens care solutions commercially available in the Iranian market, namely ReNu Multiplus (Bausch & Lomb, Rochester, NY, USA), Solo Care Aqua (CIBA Vision, Duluth, GA, USA), and All-Clean Soft (Avizor, Spain) were evaluated. 0.9% normal saline was used as control solution. The formulation and recommended disinfection times for test solutions are shown in Table 1. Three lots of each disinfectant and triplicate samples from each lot were tested. Products were within expiration dating and were tested according to manufacturer's labeled instructions for minimum disinfection time.

Table 1 The formulation and recommended disinfection times for test solutions

Solution	*Formulations*	*Manufacturer's recommended disinfection time*
ReNu MultiPlus (Bausch & Lomb, Rochester, NY, USA)	Polyaminopropyl biguanide 0.0001%, Tetronic 1107, boric acid, sodium tetraborate and sodium chloride, edentate disosium, Hydranate	4 h
Solo Care Aqua (CIBA Vision, Duluth, GA, USA)	Polyhexanide 0.0001%, Poloxamer 407, sodium phosphate, tris and sorbitol	4 h
All-Clean Soft (Avizor, Spain)	Polyhexanide 0.0002%, EDTA, PVP, Poloxamer	4 h

Test microorganisms

The test microorganisms included the ISO standards and clinical isolation of *P. aeruginosa* and *S. aureus*. The standard strains were obtained from Iranian Research Organization for Science & Technology provided from the American Type Culture Collection (ATCC) and included *P. aeruginosa* (ATCC 9027) and *S. aureus* (ATCC 6538). Clinical isolates of these organisms were obtained from asymptomatic contact lens wearers after handling. All of the bacterial strains were grown for 18–24 h on tryptone soya agar (TSA) at 30–35 °C and then collected, using a procedure based on the ISO 14729 standards. The inocula were centrifuged and suspended in normal saline and adjusted to have final concentration of 1.0×10^7–1.0×10^8 colony-forming units per milliliter (CFU/ml)

Test procedure

Test methods were based on the procedures described in ISO 14729 Stand-alone acceptance primary criteria. Growth conditions were as described previously. According to this test method, 0.1 ml of 1.0×10^7 CFU/ml test organisms suspension was added to 10 ml of each test solution. Then, the test solutions were mixed to disperse evenly the test organisms. Inoculated test solution was stored at room temperature and sampled for viable microorganisms at the labeled minimum recommended disinfection time. Then 0.1 ml aliquot was taken from each test tube, diluted with Dey–Engley neutralizing broth and permitted to stand at ambient temperature for at least 10–15 min to neutralize the preservative and then plated in TSA and incubated at 30–35 °C for 2 to 4 days for recovering the bacteria. After incubation, the number of surviving test microorganisms was determined and then the mean logarithmic reduction was calculated.[21–22]

Results

The mean log reduction at the manufacturer's minimum recommended disinfection time for each of the multipurpose solution against all test organisms is reported in Table 2.

Based on the data in Table 1, all test solutions exceeded the required 3.0 log reduction for the recommended standard ATCC strain of *P. aeruginosa* and *S. aureus* and, therefore, all solutions met the current ISO Stand-alone primary acceptance criteria for standard type of these organisms.

Similarly, all these solutions achieved the required 3.0 log reduction in bacterial count, when they were tested against the clinical isolate of *S. aureus*. But, Solo Care and All-Clean had maximum efficacy.

Although there were differences in their efficacy, Solo Care and All-Clean met and exceeded the required 3.0 log reduction for clinical isolate of *P. aeruginosa*, but ReNu Multi-Plus failed to meet the ISO Stand-alone primary acceptance criteria for this strain (Figure 1).

Table 2 Mean log reduction after minimum recommended disinfection time (4 h)

Test organisms	*ReNu MultiPlus*	*Solo Care Aqua*	*All-Clean Soft*
P. aeruginosa ATCC 9027	5.0	5.0	4.0
P. aeruginosa clinical isolate	2.6	5.0	3.8
S. aureus ATCC 6538	5.0	5.0	5.0
S. aureus clinical isolate	3.0	5.0	5.0

Discussion and conclusions

In the present study, the ISO Stand-alone test showed differences in susceptibility to three contact lens disinfectants among clinical isolates and laboratory strains of *P. aeruginosa* and *S. aureus*.

According to previous studies, one of the test hypotheses was that the clinically isolated would be more resistant than laboratory strains.[23–28] This hypothesis is confirmed by our study.

Therefore, it is clear that the ISO Stand-alone procedure does not ensure disinfectant efficacy during normal use, as demonstrated by the many reports of microbial contamination.[29–31]

Although it has been shown that the cleaning and rinsing steps of contact lens care regimen can remove more than 90% of the microbial contaminations from the lenses before the disinfection step,[32] non-compliance is very high among contact lens wearers. According to the report of Turner *et al*,[33] 30% of contact lens users do not always clean their lenses before disinfection and 44% of them do not wash their hands before handling lenses; this indicates the importance of a good disinfection.

Similar to previous studies,[23–28] the present study showed that the efficacy of a contact lens disinfecting solution is dependent on the type of strains that are used as the challenge organism. Currently clinical strains of microorganisms do not get evaluated by standard test methods. There is a need for developing a new standard protocol for testing contact lens disinfecting solutions. Additionally, despite the use of contact lens disinfecting solution, it is still essential that contact lens wearers are recommended to comply with the manufacturer's labeled instructions for care regimen.

Summary

What was known before

- Contact lens solutions are able to disinfect bacterial contamination of contact lenses.

What this study adds

- Some of contact lens solutions are not exactly efficacious as thought to be.

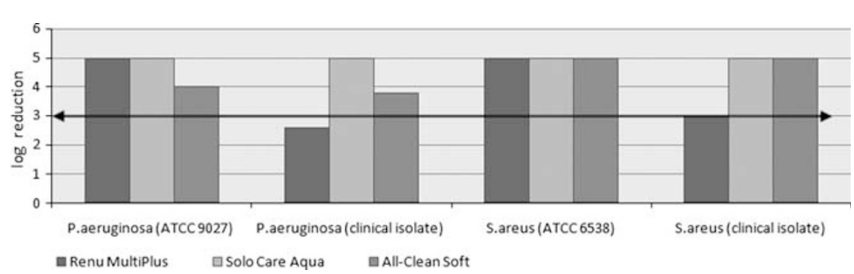

Figure 1 Antibacterial efficacy: comparison between clinical and standard strains. Horizontal line at the 3 log mark to indicate that this is the level that a solution must attain to meet the ISO criteria for contact lens care products.

Conflict of interest

The authors declare no conflict of interest.

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