

Short communication

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EVALUATION OF THE EFFICACY OF ANTIMICROBIAL ACTIVITY OF CONTACT LENS CARE SOLUTION

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Abstract

Contact lens care solutions are necessary for proper hygiene of contact lenses. Numerous microorganisms can be transmitted through them, leading to serious eye infections, while blindness can occur in particularly severe cases. A direct link between ocular infections and contact lens care solutions has been proven. Commercial preparations must meet a number of safety and antimicrobial efficacy requirements. This paper presents examinations of antimicrobial efficacy of commercial preparation called LENS CARE. The examinations were carried out according to ISO 14729:2012 standard Stand-alone test. It has been found that commercial preparation LENS CARE within proscribed contact lens care regimen of 8h meets the primary criteria of the Stand-alone test for *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans* with the results of 3.4, 3.6 and 1.0 log₁₀ reductions, respectively. If used in accordance with the manufacturer's instructions, the tested preparation has the desired antimicrobial effect against the tested pathogens.

Key words: medical device, stand-alone test

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ISPITIVANJE EFIKASNOSTI ANTIMIKROBNE AKTIVNOSTI PREPARATA ZA ODRŽAVANJE KONTAKTNIH SOČIVA

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Kratak sadržaj

Rastvori za održavanje kontaktnih sočiva su neophodna za pravilno održavanje higijene kontaktnih sočiva. Preko kontaktnih sočiva se mogu preneti brojni mikroorganizmi koji dovode do ozbiljnih infekcija oka, a u naročito ozbiljnim slučajevima može nastati slepilo. Postoje dokazi o direktnoj povezanosti epidemija okularnih infekcija sa sredstvima za održavanje kontaktnih sočiva. Komercijalni preparati moraju da ispunjavaju brojne zahteve legislative u pogledu bezbednosti i antimikrobne efikasnosti. U radu je opisano ispitivanje antimikrobne efikasnosti komercijalnog preparata pod nazivom LENS CARE. Ispitivanja su izvršena prema zahtevima standarda ISO 14729:2012 - Stand-alone test i ustanovljeno je da komercijalni preparat LENS CARE u propisanom vremenu delovanja od 8h ispunjava primarne kriterijume Stand-alone testa za *Pseudomonas aeruginosa*, *Staphylococcus aureus* kao i *Candida albicans* sa rezultatima od 3,4, 3,6 i 1,0 log₁₀ redukcija. Ukoliko se koristi u skladu sa uputstvom proizvođača preparat ima efikasno antimikrobno dejstvo prema ispitanim patogenima.

Ključne reči: medicinsko sredstvo, stand-alone test

INTRODUCTION

Contact lenses are medical devices that make life much easier for people who need vision correction, they are applied directly to the cornea and can affect eye health. Microbial keratitis – corneal infection is a sight-threatening emergent ophthalmic disease. The disease is a treatable infection but can lead to a number of complications such as corneal perforation, opacification, endophthalmitis (Jin et al., 2017). The occurrence of microbial keratitis caused by *Pseudomonas aeruginosa*, *Staphylococcus aureus* or *Fusarium* spp. linked with contact lenses has been directly proved (Jalbert et al., 2000; Ma et al., 2009).

Proper use of contact lenses and their care ensures eye health. Wearing lenses during the night, wearing them for multiple days, improper cleaning

and disinfection, their improper storage, poor hygiene of lens storage box, and poor personal hygiene of patients can lead to eye infections (Agi et al., 2021). A great risk factor for the occurrence of infections is the sterility and efficiency of lens care solutions. The outbreak of fungal keratitis occurred during 2005 and 2006 in the USA, Hong Kong and Singapore. More than 200 people became ill and the infection occurred only in people who wore contact lenses and used lens care solution "B&L ReNu with MoistureLock solution". During the epidemiological investigation, it was determined that the product was sterile, leading to a conclusion that weak antimicrobial activity of the product in combination with poor hygienic practices of the patients caused the infection. It is also believed that storage conditions after opening of the solution led to a significant reduction in its antimicrobial activity, temperature and number of days of storing the open product (Ma et al., 2009).

Table 1. Stand-alone test criteria (SRPS EN ISO 14729:2012)

Microorganism	Criteria	Average log 10 reductions at contact lens care regimen
Bacteria	Primary criteria	3.0
	Secondary criteria	The minimum acceptable log reduction for any single bacterial type is 1.0
Fungi	Primary criteria	1.0
	Secondary criteria	Stasis at contact lens care regimen

It is necessary to prove that lens care solutions are suitable for intended use, i.e. it is necessary to prove that the product has an adequate biocidal effect. In the case of agents intended for cleaning and disinfection of contact lenses, it is necessary to prove that the level of antimicrobial activity is appropriate, i.e. that the contact lens care regimen is designed to meet at least minimal performance (secondary) criteria of the Stand-alone test - ISO 14729:2012. The criteria are shown in Table 1. Primary criteria of 3.0 log reductions means that mean microorganism reduction is at least 99.9% and secondary criteria of 1.0 log reduction means that mean microorganism reduction is at least 90%.

The paper presents the results of testing the efficiency of the commercial preparation LENS CARE during the contact lens care regimen (8h).

MATERIAL AND METHODS

Product

The paper presents the results of examination of a commercial preparation called LENS CARE, which is intended for washing, removing proteins and lipids, disinfecting, moisturizing and storing all types of soft contact lenses. The preparation is sterile on the basis of 0.0001% polyhexanide. Three product lots were examined (Lot 1, Lot 2, and Lot 3). Manufacturer recommends contact lens care regimen of 8h.

Methods

The tests were performed according to the procedure described in SRPS EN ISO 14729: 2012 Ophthalmic optics — Contact lens care products — Microbiological requirements and test methods for products and regimens for hygienic management of contact lenses and European Pharmacopeia 8.0. Stand-alone test is inoculum challenge test. This test challenges a disinfecting product with a standard inoculum of microorganisms and establishes the extent of their viability loss (log of number of decimal reductions) at recommended contact lens care regimen.

The following challenge organisms were used in the tests - reference microorganisms: *S. aureus* ATCC 25923, *P. aeruginosa* ATCC 9027 and *C. albicans* ATCC 10231. The microorganisms were grown on TSA (Trypticase Soy Agar) at 30 – 35 °C for 24 h (bacteria) and on SAB (Sabouraud agar) 20 – 25 °C for 24 – 48 h (*C. albicans*). Stock inoculums in peptone salt solutions were made from reference microorganisms and they were assigned total aerobic bacteria/mold count (TAMC/TYMC) and then they were added to the LENS CARE solution in order to achieve the final concentration of 5 log cfu/mL LENS CARE. The total count of challenge organisms was enumerated after 8 h. Three lots of products were tested, each challenge organism was tested in three samples and the determination of the number of microorganisms was performed in duplicate by seeding on TSA/SAB media. These media were incubated at 30 - 35 °C for 72 h (TSA) and at 20-25 °C for 5 days (SAB).

Total count of challenge organisms is shown according to log₁₀ base. Descriptive statistics and *p* value was calculated using IBM SPSS Statistics 20 (IBM, Armonk, NY, USA). The results of the statistical tests were considered significant for *p* < 0.05.

RESULTS AND DISCUSSION

In the past, several disinfectants were used for disinfection of contact lenses, for example first unpreserved saline and then disinfectants. Nowadays, all in one multipurpose product is mainly used for cleaning, disinfection and re-wet in one use. Modern preparations are usually based on polyhexamethylene biguanide (PHMB) with polyaminopropyl biguanine (ReNu) or polyquaternium-1 with myristamidopropyl dimethylamine (Opti-Free), while some preparations contain only one biocide polyhexanid or polyhexamethylene biguanide (Lite, Complete Easy Rub, SOLO-care) (McAnally et al. 2021). LENS CARE is in the group of preparations with one biocide. In order to compare the results with other studies, it must be taken into account whether Stand-alone or Regimen test is used for testing, since lens care solutions have lower antimicrobial activity in the presence of contact lenses (Regimen test), depending on the type of the microorganism being tested. Commercial solutions based on PHMB reacts most with silicone hydrogel and hydrophilic soft contact lenses, which leads to a decrease in the concentration of PHMB and a decrease in antimicrobial activity (Gabriel et al. 2018; McAnally et al. 2021).

The decline in antimicrobial activity in the presence of lenses is one of the reasons why the requirements for the Stand-alone test (primary criteria) are stricter compared to the Regimen test (secondary criteria), where only one decimal reduction is sufficient (Table 1.). The results of the LENS CARE solution efficiency test are shown in Table 2 expressed as a number of decimal reductions after the contact lens care regimen (8h). TAMC/TYMC values are expressed an average values of duplicate enumeration.

Table 2. Efficacy results of three lots of LANS CARE solution – Stand-alone test

Lot	No of microorganisms (log10 cfu/mL)	<i>S.aureus</i> ATCC 25923	<i>P. aerugi- nosa</i> ATCC 9027	<i>C. albicans</i> ATCC 10231
Lot 1	Initial concentration	5.9	5.3	4.7
	TAMC/TYMC	2.1	2.2	3.7
	No of decimal reductions	3.8	3.1	1.0
Lot 2	Initial concentration	5.6	4.9	4.2
	TAMC/TYMC	1.9	1.9	3.2
	No of decimal reductions	3.7	3.0	1.0
Lot 3	Initial concentration	5.1	5.5	4.6
	TAMC/TYMC	1.7	1.4	3.5
	No of decimal reductions	3.4	4.1	1.1
Average ± SD	No of decimal reductions	3.6 ± 0.2	3.4 ± 0.6	1.0 ± 0.1

TAMC – total aerobic microbial count, TYMC – total combined yeasts/moulds count, cfu – colony forming unit

Commercial lens care solutions are effective against most major eye pathogens. Antimicrobial activity depends on the type and amount of biocide contained in the preparation, and also on the method of use (Zhu et al., 2011; Gabriel et al. 2018).

S. aureus is a pathogen that can lead to eye infection, it is most commonly transmitted by hands. However, eye infections caused by the use of contact lenses have also been proven (Jalbert et al., 2000). *S. aureus* has the ability to form a biofilm on various surfaces and thus significantly reduces the effectiveness of detergents and disinfectants. Compared with the results of testing of other commercial preparations (Ewbank 2000; Rosenthal et al., 2003; Kal et al., 2017; Gabriel et al., 2018), it was found that LENS CARE provides a slightly higher number of decimal reductions of *S. aureus* after the recommended time (3.6 log reductions) than Opti-Free preparation (3.2 – 3.3 log reductions) and a slightly lower than SOLO-care preparation (4.2 - 4.9 log reductions) and ReNu preparation (3.9 - 5.0 log reductions). However, there are significant differences between the studies - Kal et al., (2017) found that Opti-Free provides 1.9 log reductions of *S. aureus*, unlike Gabriel et al. (2018) who identified 4.0 –5.0

log reductions. Although they used the same commercial preparation (Opti-Free Express), the same recommended time (6h) and the same test (Regimen), there were differences in the results. A possible explanation could be the differences in the contact lenses on which the test was performed or the differences in the design and implementation of the study itself.

Keratitis caused by *P. aeruginosa* is the most common type of infection transmitted through contact lenses (Agi et al., 2021). Corneal infection can develop in just a few hours (Wilson et al., 1981), so it is essential that contact lens care products are effective against this microorganism. In relation to antimicrobial activity against *P. aeruginosa*, LENS CARE is slightly less effective (3.4 log reductions) than SOLO-care (3.5 - 3.8 log reductions), ReNu and Opti-Free (4.0 - 5.0 log reductions), according to data presented by Kal et al., (2017), Ewbank (2000) and Gabriel et al. (2018). However, in a study by Kal et al., (2017) it was reported that ReNu Multi Plus leads to less than 2.9 log reductions after the recommended time (4h), while, using the same Regimen test, Gabriel et al. (2018) found that ReNu Fresh provides 4.2 log reductions, although ReNu Multi Plus contains 0.001% polyaminopropyl biguanide and ReNu Fresh 0.0001%.

SOLO-care preparation is the most similar in composition to LENS CARE preparation (0.0001% polyhexanide). Producers recommend a different contact lens care regimen for SOLO-care (4 hours), while it is 8 hours for LENS CARE. SOLO-care is somewhat more effective against *S. aureus* and *P. aeruginosa* compared with data of Ewbank 2000 and Kal et al., 2017.

C. albicans can cause fungal keratitis, although somewhat less frequently (14%) compared to *Fusarium* species (41%) (Iyer et al., 2006). *Candida* eye infections usually occur either after trauma or after the use of corticosteroids, and it is more common in colder climates. Still, the main risk factor for all fungal keratitis is wearing contact lenses (Iyer et al., 2006, Imamura et al, 2008). Transmission of *C. albicans* through contact lenses is facilitated by their ability to form biofilms (Imamura et al., 2008). The biofilm that *Candida* forms is tightly bound to hydrogel and silicone contact lenses, so the effect of lens care solutions is much weaker against *Candida* compared to bacteria (Zhu et al., 2011). The effect of LENS CARE contact lens care products achieves at least one decimal reduction of *C. albicans* after recommended time, which is statistically significantly less effective than challenge bacteria but still meets the primary criteria of the Standalone test. Similar results were obtained by Imamura et al (2008) for ReNu Moisture Loc and ReNu Multi Plus, while Gabriel et al. (2018) found that there is less than one decimal reduction for the ReNu Fresh preparation. Preparations based on polyquaternium and myristamidopropyl

dimethylamine have much higher antimicrobial activity (1.5- 4.5 log reductions) but only on the stand-alone test while their activity drops below 1 log reduction in the presence of lenses (Gabriel et al., 2018).

There are no statistically significant differences between the effect of the LENS CARE solution on *S. aureus* compared to *P. aeruginosa* ($p = 1.0$), but the number of decimal reductions of *C. albicans* is significantly lower than *S. aureus* ($p = 0.00003$) and *P. aeruginosa* ($p = 0.00001$).

CONCLUSION

LENS CARE solution is sufficiently effective and meets the requirements of the Stand-alone test in terms of antimicrobial efficacy against to *S. aureus*, *P. aeruginosa* and *C. albicans* at the recommended time of 8 h. In order for the preparation to show its maximum efficiency, it is necessary to follow the labeling instructions of the manufacturers.

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Author's Contribution

This paper was written as a review paper which dealt with a series of papers in the field of microbial quality of pharmaceutical products. All authors of this paper have participated in the writing of this paper and previous research. Writing paper JP and RR, examinations JP and IS, and data processing JP and NV.

Competing interest

The authors declare that they have no competing interest.

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