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Review

Contact lens hygiene compliance and lens case contamination: A review

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ABSTRACT

A contaminated contact lens case can act as a reservoir for microorganisms that could potentially compromise contact lens wear and lead to sight threatening adverse events. The rate, level and profile of microbial contamination in lens cases, compliance and other risk factors associated with lens case contamination, and the challenges currently faced in this field are discussed. The rate of lens case contamination is commonly over 50%. Coagulase-negative Staphylococcus, Bacillus spp., *Pseudomonas aeruginosa* and *Serratia marcescens* are frequently recovered from lens cases. In addition, we provide suggestions regarding how to clean contact lens cases and improve lens wearers' compliance as well as future lens case design for reducing lens case contamination. This review highlights the challenges in reducing the level of microbial contamination which require an industry wide approach.

1. Contact lens related microbial keratitis

Contact lens wear is usually considered a safe and effective means to correct refractive error, however, adverse reactions may occur. The most significant complication is microbial keratitis, a microbial infection which leads to corneal ulceration, a vision threatening condition. Contact lens wear accounts for 65% of all new cases of microbial keratitis in the UK [1]. Similar figures have also been reported in Holland (63%) [2], Taiwan (53%) [3] US (52%) [4] and Japan (55%) [5]. In the late 1990s, the incidence of contact lens related microbial keratitis was estimated to be 2.2–4.1 per 10,000 wearers of soft daily wear lenses and 13.3–20.9 per 10,000 wearers of soft extended wear [6–8]. With contemporary contact lens wear the annualized incidence is essentially unchanged for daily and extended wear use [9].

It has been found that the disease severity is lower in microbial keratitis patients wearing daily disposables than those wearing other modalities [9,10]. This perhaps supports the hypothesis that lens case hygiene still plays an important role in safe contact lens wear and this is shown in recent epidemiological studies [11].

Many epidemiological studies have identified risk factors for contact lens related microbial keratitis. Some of the modifiable behavioral factors include infrequent disinfection of contact lenses [1,12], overnight wear [13–15], smoking [14,16,17,8], inadequate hand washing [8] and poor lens case hygiene [8].

1.1. The relevance of storage case contamination

Colonization of the lens storage cases by pathogenic microorganisms may predispose lens wearers to microbial or sterile keratitis [18–22]. It has also been demonstrated that identical organisms have been identified from both a lens storage case and cornea ulcer [23]. A recent study by Wiley et al. has demonstrated that lens case contamination, in particular biofilm formation may lead to the development of contact lens related microbial keratitis [24]. Further, the study also found that the disease severity correlates with an increase in the diversity of bacterial types found in lens cases [24].

Lens case contamination rate ranges from 18% to 85% (Table 1). The geographical location in which the various studies were conducted, study design, microbiological sampling and methods, subject factors and sample size may account for the wide variation in lens case contamination rates. For example, the study by Simmons et al. looked at the contamination of case wells and lids prior to handling by the subjects, which seems to explain why their contamination rates were low at 18% [25]. Wu et al. has shown that different areas of the same lens case swabbed for bacterial recovery show a different rate and profile of contamination, which may account for microbial recovery discrepancies among reported studies [26]. There are also issues regarding different microbial recovery techniques used amongst studies. *E.g.* viable but non-cultural

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Table 1
Summary of studies estimating lens case contamination rate in contact lens wearers.

Year/location	Study	Sample size and type	Lens type used (% of users using each category)	Disinfection systems used (% of users using each category)	Frequency of case contamination (%)	Frequently recovered micro-organisms NR = not reported[a]		
						Bacteria	Fungi	Protozoa
1985 (Canada)	Callender et al. [30] (cross-sectional study)	58 asymptomatic lens wearers	Soft lenses	Various chemical	72%	*S. epidermidis* *Moraxella* spp. *Enterobacter* spp.	NR	NR
1987 (US)	Donzis et al. [31] (cross-sectional study)	100 asymptomatic lens wearers	Soft (62%) Rigid (38%)	Chemical Peroxide Heat	44% 44% 32%	Coagulase-negative Staphylococcus, *Bacillus* spp.	Fusarium	NR
1989 (UK)	Larkin *et al.* [32] (cross-sectional study)	102 asymptomatic lens wearers	Soft (66%) Rigid (34%)	Chemical (61%) Peroxide (20%) Heat (19%)	Overall: 42%	Environmental pseudomonads, Gram-negative bacilli *Serratia marcescens* (range: 0–10^6 CFU)	NR	Acanthamoeba (9%)
1990 (USA)	Simmons et al. [25] (cross-sectional study)	53 lens wearers	Soft lenses	Peroxide (74%) MPS (16%)	18% 21%	*Pseudomonas* spp.	NR	NR
1990 (US)	Wilson et al. [28] (cross-sectional study)	118 asymptomatic lens wearers	Soft Rigid	Chemical Peroxide Saline Miscellaneous	Overall: 54% 11% 8% 40% 61%	*Staphylococcus epidermidis* *Micrococcus* spp. *Serratia marcescens* *Pseudomonas aeruginosa* (range: 0–10^5 CFU)	NR	NR
1992 (UK)	Devonshire et al. [33] (cross-sectional study)	178 asymptomatic lens wearers	Soft (74%) Rigid (26%)	Peroxide (22%) Chemical (42%) Chlorine (30%) Chlorhexidine tablet (3%) Others: Unknown	Overall: 53%	*Serratia marcescens* *Pseudomonas fluorescens* *Acinetobacter* spp.	Yeast	Acanthamoeba (4.5%) Hartmanella (0.75%)
1995 (NZ)	Gray et al. [27] (cross-sectional study)	101 asymptomatic lens wearers	Soft (85%) Rigid (15%)	Chemical (23%) Peroxide (75%)	Overall: 81%	*Pseudomonas* spp. *Serratia* spp. *Diphtheroids* (72% had mixed bacterial contaminations)	*Cladosporiums* spp. *Candida* spp.	*Acanthamoeba* spp. *Naegleria* spp.
1996 (Norway)	Midelfart et al. [34] (cross-sectional study)	21 asymptomatic medical students	Soft (95%) Rigid (5%)	Chemical Peroxide	Overall: 24%	*Xanthomonasmaltophilia* *Pseudomonas cepacia* *Serratia liquefaciens* *Serratia plymuthica*	NR	NR
1996 (Spain)	Velasco et al. [35] (clinical trial)	126 lens cases	Soft	Polyaminopropylbiguanide	Overall: 81%	*Staphylococcus epidermidis* *Staphylococcus aureus* *Streptococcus viridans* *Pseudomonas aeruginosa*	NR	NR
1998 (UK)	McLaughlin-Borlace et al. [36] (cross-sectional study)	20 Microbial keratitis patients	Various	Chlorine based Hydrogen peroxide Thiomersal Polyhexamethylene	Overall: 85%	*Staphylococcus aureus* *Pseudomonas aeruginosa* *Enterbacter*	NR	*Acanthamoeba* spp.
1999 (UK)	Seal et al. [37] (clinical trial)	155 lens wearers	Soft	MPS Peroxide	78% 58%	Gram + Gram − (range: 0–10^4 CFU)	NR	NR
2005 (HK)	Boost et al. [38] (clinical trial)	47 asymptomatic lens wearers	Orthokeratology	Boston Advance and Simplicity	Overall: 70%	*Acinetobacter* spp. *Pseudomonas aeruginosa* *Serratia* *Staphylococcus aureus*	0	0
2007 (HK)	Yung et al. [39] (cross-sectional study)	101 asymptomatic lens wearers	Various	Multipurpose solution	Overall: 34%	*Staphylococcus aureus* *Pseudomonas aeruginosa* *Serratia marcescens*	0	0