Personal hygiene risk factors for contact lens-related microbial keratitis

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ABSTRACT
Objective  Microbial keratitis is a sight-threatening complication of contact lens wear, which affects thousands of patients and causes a significant burden on healthcare services. This study aims to identify compliance with contact lens care recommendations and identify personal hygiene risk factors in patients who develop contact lens-related microbial keratitis.

Methods and analysis  A case–control study was conducted at the University Hospital Southampton Eye Casualty from October to December 2015. Two participant groups were recruited: cases were contact lens wearers presenting with microbial keratitis and controls were contact lens wearers without infection. Participants underwent face-to-face interviews to identify lens wear practices, including lens type, hours of wear, personal hygiene and sleeping and showering in lenses. Univariate and multivariate regression models were used to compare groups.

Results  37 cases and 41 controls were identified. Showering in contact lenses was identified as the greatest risk factor (OR, 3.1; 95% CI, 1.2 to 8.5; p=0.03), with showering daily in lenses compared with never, increasing the risk of microbial keratitis by over seven times (OR, 7.1; 95% CI, 2.1 to 24.6; p=0.002). Other risks included sleeping in lenses (OR, 3.1; 95% CI, 1.2 to 8.5; p=0.03), with people aged 25–54 being at greatest risk (OR, 7.1; 95% CI, 2.1 to 24.6; p=0.002). Risks included sleeping in lenses (OR, 3.1; 95% CI, 1.2 to 8.5; p=0.03), with people aged 25–54 being at greatest risk (OR, 7.1; 95% CI, 2.1 to 24.6; p=0.002). Risks included sleeping in lenses (OR, 3.1; 95% CI, 1.2 to 8.5; p=0.03), with people aged 25–54 being at greatest risk (OR, 7.1; 95% CI, 2.1 to 24.6; p=0.002).

Conclusion  The greatest personal hygiene risk factor for contact lens-related microbial keratitis was showering while wearing lenses, with an OR of 3.1, which increased to 7.1 if patients showered daily in lenses. The OR for sleeping in lenses was 3.1, and the most at-risk age group was 25–54.

INTRODUCTION
Contact lenses for visual correction offer many benefits to the 4 million wearers in the UK, yet contact lens-related microbial keratitis (CLMK) is a frequent cause of unilateral visual impairment. Severe cases can result in permanent vision loss, a need for corneal transplant or loss of the eye. In all healthcare systems, CLMK poses a significant healthcare challenge as patients require intensive topical antimicrobial therapy and close monitoring of treatment response.

Despite advances in contact lens technology, the incidence of CLMK has remained consistent at around 4 per 10,000 daily contact lens wearers per annum. Poor contact lens hygiene is a known contributor to microbial keratitis. In a study by Brewitt et al, 66% of complications observed in contact lens wearers were attributed to poor hygiene practices. There is great variation in contact lens hygiene awareness and recognition of the risks among regular contact lens wearers. Aftercare practices and demographic trends of contact lens wearers have been previously investigated to identify risk factors for microbial keratitis. This study aims to identify patient demographics and current
compliance with contact lens care recommendations by contact lens wearers in the UK. The study also aims to identify modifiable risk factors for patients who develop CLMK, including, types of lenses worn, lens wearing habits, aftercare habits and water exposure. Further aims included analysing patient opinions and experience on contact lens wear and microbial keratitis. Our study is unique in that we used face-to-face interviews, to be able to accurately capture patient hygiene practices and experiences of CLMK.

METHODS

In this study, we interviewed contact lens wearers to compare contact lens hygiene practices in lens wearers with CLMK (cases) and lens wearers without infection (controls). Ethics committee approval was obtained from University of Southampton Ethics and Research Governance Online (ERGO reference: 14394).

Participant recruitment

Contact lens wearers attending University Hospital Southampton Eye Casualty between October 2015 and December 2015 were identified. A convenience sampling method was adopted, whereby patients who were identified to be contact lens wearers at triage were approached to take part. Participants were included if they were aged 18–75 and had worn refractive or cosmetic contact lenses for the last 30 days before attendance. Participants with therapeutic lenses, other ocular surface disease, herpes simplex keratitis, significant mental illness or learning disability were excluded.

Cases of CLMK were defined as contact lens wearers having a diagnosis of microbial keratitis made by an ophthalmologist for the first time or within the preceding 1 month prior to interview. Only patients with active infection, and who were still being treated or followed up for CLMK were included. Microbial keratitis was defined as 1. a positive culture from a corneal scrape or 2. a corneal infiltrate and overlying epithelial defect associated with either i. the lesion being within central 4 mm of the cornea, or ii. uveitis.

Controls were defined as contact lens wearers attending Eye Casualty for non-contact lens-related problems, and who had no previous history of corneal or infective complications from contact lens wear.

Data collection and questionnaires

Participants were given a patient information sheet and consent was obtained. A single trained researcher who had a medical background but was external to the eye department, conducted face-to-face interviews in a private room using a standardised questionnaire. The questionnaire was designed by the research team, after trialling it in a pilot study with patients. The questionnaire was internally validated by the research team, after trialling it in a pilot study with patients with CLMK. The questionnaire was further improved based on the patient preferences and experiences of CLMK identified during the pilot study. Our study was designed to be conducted via face-to-face interviews, due to patient preference.

RESULTS

Demographics and contact lens types

Seventy-eight participants were recruited into the study (41 controls, 37 cases of CLMK), and no participants dropped out. Patient demographics and baseline characteristics are shown in table 2. Soft monthly disposable contact lenses were the most commonly worn (43%) contact lens type in our cohort. Table 2 also shows the breakdown of contact lens type and frequency of wear.

Univariate analysis

Univariate analysis was used to calculate risk factors for CLMK, as shown in table 3. Watering in lenses was the greatest modifiable risk factor (OR, 3.1; 95% CI, 1.2 to 8.5; p=0.025), with a dose-dependent effect. The OR for watering in lenses daily, compared with never, was 7.1 (OR, 7.1; 95% CI, 2.1 to 24.6; p=0.002). Sleeping in contact lenses also increased the risk of microbial keratitis (OR, 3.1; 95% CI, 1.1 to 8.6; p=0.026), as did being aged 25–39, when compared with being aged >55 (OR, 6.38; 95% CI, 1.56 to 26.10; p=0.010).

Multivariate analysis

The multivariate analysis model showed that age, contact lens type and watering in lenses were risk factors which reached statistical significance (table 4). The OR for being aged 25–39 was 8.16 (95% CI, 1.45 to 46.05;...
p=0.017), and the OR for being aged 40–54 was 7.78 (95% CI, 1.31 to 36.28; p=0.024), when compared with being aged >55. The OR for showering daily in lenses was 13.73 (95% CI, 2.35 to 80.07; p=0.004), when compared with never showering in lenses. The OR for wearing soft daily disposable was 16.76 (95% CI, 1.09 to 257.56; p=0.043) and soft 2-week disposable was 26.07 (95% CI, 1.18 to 577.16; p=0.039).

**Visual outcomes and attitudes towards contact lenses after CLMK**

In our cohort, the majority of patients felt that their infective episode had not resulted in significant visual loss. About 55.6% of patients with CLMK (n=20) felt that their infective episode had affected their quality of life, and of these patients, the breakdown of how their life was affected is shown in figure 1A. Figure 1B shows subjective visual outcomes following CLMK. Most patients (86.5%, n=32) had not considered discontinuing contact lens wear after an infective episode of microbial keratitis. Of the few patients who wished to discontinue contact lens wear (13.5 %, n=5), the greatest reason was fear of having another infection (n=3), fear of permanent sight loss (n=1) and recurrent memories of symptoms (n=1).

**Responsibility of contact lens education**

Participants were asked if they were told the risks of infections when first prescribed contact lenses, and nearly half of both patients with CLMK and control groups responded with either ‘no’ or ‘not sure’. The responses were not statistically different between controls and patients with CLMK (figure 1C). Participants were asked whom they felt was responsible for providing education about contact lens-related complications. Ninety-two (n=71) per cent of respondents felt that contact lens education was the responsibility of the ‘optician’, 13.0% (n=10) stated ‘self’ and 1.3% (n=1) stated ‘doctor’ (with some participants choosing more than one option). Participants were asked how they thought advice and instructions about contact lens wear should be given. About 54.5% (n=42) of participants felt written information, 68% (n=52) felt verbal information and 48% (n=37) felt demonstrations (48.1 %, n=37) would help improve education.

**Compliance with annual contact lens aftercare appointments with optician**

About 80.8% (n=63) of all participants in the study were compliant with attending appointments at least annually. About 83.7% (n=31) of patients with microbial keratitis, and 78% (n=32) of controls reported that they were attending appointments at least annually.

**DISCUSSION**

**Risk factors for CLMK**

Our study is unique in that, not only does it investigate risk factors for microbial keratitis, but it also analyses the
opinions of patients after corneal infection. This gives useful insight into how contact lens practitioners can improve patient education and compliance. This was only possible with face-to-face interviews as it allowed for a lot of detail to be gathered from participants, and also ensured full completion of the questionnaire. Completing the questionnaire did not lengthen waiting times, which meant that no patients dropped out of the study. Our most significant risk factors for CLMK identified included showering in contact lenses, being aged 25–54 and wearing certain soft contact lenses.

Monthly contact lenses were the most frequently used contact lens type in our patient cohort. All forms of contact lens wear increase the risk of microbial keratitis but monthly and extended wear contact lenses have previously been shown to increase risk of sight loss. Although monthly disposable lenses also increase the risk of infection, this did not reach statistical significance. In our patient group, 10.8% of patients reported significant sight loss, while 56.8% reported no change in their vision. *Pseudomonas aeruginosa* is the most commonly identified pathogen among contact lens wearers followed by...
Gram-positive organisms. P. aeruginosa is able to adhere and colonise contact lens materials during lens wear, survive in contact lens storage cases and has resistance to contact lens disinfectants. Acanthamoeba are free-living
Following an episode of CLMK, very few of our patients considered discontinuing contact lens wear. Of those whose quality of life or vision had been affected by the infection, 80% (n=20) wished to continue wearing their lenses, demonstrating the benefits that contact lens wear provide but also the importance of instilling good contact lens hygiene awareness and reinforcing this information when attending eye casualty. A large number of our participants (92.2%, n=72) identified the optician as being responsible for providing information about contact lens-related complications. Nearly half of all participants in both control and CLMK groups could not recall or were unsure if they were told specifically about the risks of contact lens-related infections when first prescribed their contact lenses (figure 1c).

Under guidance from College of Optometrists UK, contact lenses can only be fitted and prescribed by optometrists, doctors and contact lens opticians. Dispensers of contact lenses are required to give training and information about lens care, hygiene and wear schedules before lenses can be dispensed. About 89.2% (n=33) of the patients who developed microbial keratitis, stated that an optician supplies them with their contact lenses. The British Contact Lens Association (BCLA) recommends contact lens aftercare appointments at least annually. As shown in table 3, non-compliance with annual aftercare appointments was not found to be a risk factor for microbial keratitis. There was a high level of reported compliance in attending annual follow-up appointments, in both cases and control group. A 2010 Australian study19 looking at contact lens compliance found similar results.

These findings are rather confusing, as despite regular follow-up with opticians and perceived good concordance with BCLA recommendations, patients’ understanding and retention of contact lens hygiene and risk behaviour remains low. As patients are likely to want to continue wear lenses even after an infective episode, contact lens practitioners should focus efforts on improving patient retention of information about infections and aftercare practices, because persuading patients to stop wearing contact lenses may be ineffective.

Our study demonstrated that all three forms of information—verbal, demonstrations and written—were important for contact lens wearers to improve education about lens wear and complications. A possible way to increase awareness may be to supply printed material with each contact lens box to remind them about risks and aftercare practices.

A limitation of the study was that controls were also eye casualty attendees, presenting with other ocular problems, which could have introduced bias into the control group. These patients, however, presented with non-ocular surface problems and non-contact lens-related issues, which were typical for any person attending the department. To limit recall bias in the CLMK cases group, only patients who were newly diagnosed with CLMK and still had active infection were included in the study. The questionnaire used was developed and validated by the

| Table 4 Independent risk factors for CLMK identified by multiple logistic regression analysis |
|---|
| Risk factor | OR | 95% CI | P value |
| Age | | |
| >55 | 1.00 (referent) | | |
| <24 | 1.78 | 0.28 to 11.26 | 0.541 |
| 25–39 | 8.16 | 1.45 to 46.05 | 0.017* |
| 40–54 | 7.78 | 1.31 to 46.28 | 0.024* |
| Contact lens type† | | |
| RGP | 1.00 (referent) | | |
| SDD | 16.76 | 1.09 to 257.56 | 0.043* |
| STWD | 26.07 | 1.17 to 577.16 | 0.039* |
| SMD | 10.33 | 0.72 to 148.27 | 0.086 |
| SEW | 1.58 | 0.04 to 71.50 | 0.813 |
| Frequency of showering in contact lenses | | |
| Never | 1.00 (referent) | | |
| Few times a year | 0.38 | 0.03 to 4.89 | 0.454 |
| Few times a month | 1.55 | 0.27 to 8.90 | 0.626 |
| Few times a week | 3.24 | 0.58 to 18.05 | 0.181 |
| Daily | 13.73 | 2.35 to 80.07 | 0.004** |

*p<0.05. **p<0.01.
†Two contact lens types unknown and excluded in this analysis. RGP, rigid gas permeable; SDD, soft daily disposable; SEW, soft extended wear; SMD, soft monthly disposable; STWD, soft 2-week disposable.

...
research team, and face-to-face interviews were chosen to accurately obtain data. To limit interviewer bias and limit influencing participant responses, only one researcher who was not involved in patient care, conducted the interviews in a standardised manner. A limitation was that the OR and CI ranges in the multivariate model were large. A larger sample size would be needed to calculate a more precise estimate of effect.

Risk factors that could be investigated further include: overall duration (eg, in years) of contact lens wear, smoking history, socioeconomic status, ethnicity and reason for contact lens wear (hyperopia, myopia, presbyopia or cosmetic). A multicentre study with a larger sample size could reduce sample bias, help evaluate risks and demographics further, and could show trends on regional and national levels. Precision and the number of significant results may also be improved. An interesting area for future work would be to further investigate the effect of showering in contact lenses, and to identify which organisms are isolated in patients with CLMK who shower in lenses.

The major personal hygiene risk factors for CLMK include showering, especially daily, in contact lenses and sleeping in lenses. Patients aged 25–54 are the most at-risk group. Despite most contact lens wearers buying their lenses from opticians and having regular follow-up appointments, contact lens wearers continue to perform poor hygiene practices and risk developing microbial keratitis. Focusing attention on improving education of infection and retention of information may help improve compliance with lens wear practices, which may help reduce incidence of CLMK and associated sight loss.

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Figure 1  Graphs showing how the recent CLMK episode (A) subjectively affected patients’ vision (B) and quality of life (more than one option could be chosen for this question) and (C) Responses for question: ‘Were risks of infections explained when lenses first prescribed?’ CLMK, contact lens-related microbial keratitis.
REFERENCES

1. Dart JK. Predisposing factors in microbial keratitis: the significance of contact lens wear. *Br J Ophthalmol* 1988;72:926–30.
2. Dart JK, Stapleton F, Minassian D. Contact lenses and other risk factors in microbial keratitis. *Lancet* 1991;338:650–5.
3. Bourcier T, Thomas F, Borderie V, et al. Bacterial keratitis: predisposing factors, clinical and microbiological review of 300 cases. *Br J Ophthalmol* 2003;87:834–8.
4. Hoddenbach JG, Boekhoorn SS, Wubbels R, et al. Clinical presentation and morbidity of contact lens-associated microbial keratitis: a retrospective study. *Graefes Arch Clin Exp Ophthalmol* 2014;252:299–306.
5. Morgan PB, Efron N, Hill EA, et al. Incidence of keratitis of varying severity among contact lens wearers. *Br J Ophthalmol* 2005;89:430–6.
6. Poggio EC, Glynn RJ, Schein OD, et al. The incidence of ulcerative keratitis among users of daily-wear and extended-wear soft contact lenses. *N Engl J Med* 1989;321:779–83.
7. Stapleton F, Keay L, Edwards K, et al. The incidence of contact lens-related microbial keratitis in Australia. *Ophthalmology* 2008;115:1647–54.
8. Brewitt H. [Contact lenses. Infections and hygiene]. *Ophthalmologe* 1997;94:311–6.
9. Dart JKG, Radford CF, Minassian D, et al. Risk factors for microbial keratitis with contemporary contact lenses: a case-control study. *Ophthalmology* 2008;115:1647–54.
10. Lim CHL, Carnt NA, Farook M, et al. Risk factors for contact lens-related microbial keratitis in Singapore. *Eye* 2016;30:447–55.
11. Radford CF, Bacon AS, Dart JK, et al. Risk factors for Acanthamoeba keratitis in contact lens users: a case-control study. *BMJ* 1995;310:1567–70.
12. Stapleton F, Edwards K, Keay L, et al. Risk factors for moderate and severe microbial keratitis in daily wear contact lens users. *Ophthalmology* 2012;119:1516–21.
13. Pesudovs K, Burr JM, Harley C, et al. The development, assessment, and selection of questionnaires. *Optom Vis Sci* 2007;84:663–74.
14. Dutta D, Cole N, Willcox M. Factors influencing bacterial adhesion to contact lenses. *Mol Vis* 2012;18:14–21.
15. Joslin CE, Tu EY, Shoff ME, et al. Shifting distribution of Chicago-area Acanthamoeba keratitis cases. *Arch Ophthalmol* 2010;128:137–9.
16. Chew HF, Yildiz EH, Hammersmith KM, et al. Clinical outcomes and prognostic factors associated with Acanthamoeba keratitis. *Cornea* 2011;30:435–41.
17. Cavanagh HD, Ladage PM, Li SL, et al. Effects of daily and overnight wear of a novel hyper oxygen-transmissible soft contact lens on bacterial binding and corneal epithelium: a 13-month clinical trial. *Ophthalmology* 2002;109:1957–69.
18. Wu Y, Carnt N, Stapleton F. Contact lens user profile, attitudes and level of compliance to lens care. *Cont Lens Anterior Eye* 2010;33:183–8.