Clinical Ophthalmology

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Microbial Keratitis Before, During and After the COVID-19 Pandemic, and the Role of Contact Lens Wear and Hand Hygiene

Anna C Randag[1,2], Liesbeth Wellens[1], Nelly Kazemian[1], Barbara Schimmer[3], Jeroen van Rooij[1,2]

[1]Department of Cornea and Anterior Segment Disease, Rotterdam Eye Hospital, Rotterdam, The Netherlands; [2]Rotterdam Ophthalmic Institute, Rotterdam, the Netherlands; [3]Center for Infectious Disease Control, National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands

Correspondence: Anna C Randag, Rotterdam Ophthalmic Institute, Schiedamse Vest 160, 3011 BH Rotterdam, The Netherlands, Email a.randag@oogziekenhuis.nl

Introduction: During the COVID-19 pandemic, there was a significant decline in the number of patients with both non-urgent and urgent ophthalmologic conditions presenting to emergency departments, leading to concerns about the whereabouts of patients in need of care. We hypothesized that there was an actual decrease in microbial keratitis (MK) cases, due to reduced contact lens (CL) wear and improved hand hygiene, including alcohol-based hand disinfection. Besides, we questioned if non-pharmaceutical interventions would have a sustained effect after the COVID-19 pandemic.

Methods: Retrospectively, characteristics of patients presenting with MK at a large ophthalmic tertiary referral center were compared during 9 March–15 June of 2018 and 2019 ("pre-COVID"), 2020 ("COVID") and 2022 and 2023 ("post-COVID"). In an online cross-sectional survey among CL wearers, CL wear and hand hygiene habits were compared for the recall months February and April 2020.

Results: Three hundred and one MK patients were included: 79 in 2018, 69 in 2019, 41 in 2020, 60 in 2022 and 52 in 2023. Presentation delay was ≥4 days in 38% during COVID, compared to 54% pre-COVID ($p = 0.106$). The proportion of CL related MK did not differ ($p = 0.704$). Fewer patients were admitted than pre-COVID ($p = 0.026$), without a difference in admission indications ($p = 0.322$). *Pseudomonas aeruginosa* and *Staphylococcus aureus* cases were not observed during COVID. Post-COVID, MK by *Pseudomonas aeruginosa* occurred more often than pre-COVID ($p < 0.001$). In the online survey with 791 respondents, hand washing before CL insertion and removal and hand disinfection were reported more often in April 2020 than February 2020 (respectively, $p = 0.001$, $p < 0.001$ and $p < 0.001$).

Conclusion: We found no evidence of MK patients facing barriers to accessing hospital care during the COVID-19 pandemic, as presentation delays were not longer and cases not more severe. Our data suggest that a decreased MK incidence may be due to improved hand hygiene practices, including alcohol-based hand disinfection.

Keywords: microbial keratitis, COVID-19, lockdown, hospital admissions, hand disinfection, pseudomonas aeruginosa

Introduction

At the start of the COVID-19 pandemic in 2020, strict national lockdowns were implemented worldwide. The Dutch government adopted an "intelligent lockdown" strategy on 23 March 2020: people were urged to work and stay at home as much as possible, but were allowed to leave their homes as long as a 1.5 meter distance to other individuals was respected.[1] Besides, there was repeated emphasis on strict hand hygiene, starting with an imposition of four non-pharmaceutical interventions (NPIs) on 9 March 2020: 1) washing hands thoroughly, 2) coughing and sneezing in the elbow, 3) using paper tissues instead of cotton handkerchiefs and 4) no more hand shaking.[1] On 1 June 2020, a first relaxation of measures was announced, after which some public venues, such as cinemas, theaters and museums, reopened, while maintaining the requirement for visitors to keep a 1.5 meter distance to one another.[1]

Received: 17 December 2024
Accepted: 20 February 2025
Published: 21 March 2025

Hospitals, including the Rotterdam Eye Hospital (REH), put restrictions on non-urgent procedures and outpatient visits, but emergency care departments remained operational 24 hours a day to treat patients with life- and sight-threatening conditions. In several Western European countries, a shift occurred among ophthalmologic conditions seen at emergency care departments: compared to pre-pandemic times, conjunctivitis and blepharitis were diagnosed less frequently, while the proportion of patients presenting with keratitis increased.[2–4] One of the main hypotheses was that conjunctivitis and blepharitis were managed more often by the general practitioner, while patients presenting with microbial keratitis (MK), an often painful condition with effect on visual acuity, were still seen by the ophthalmologist.[4,5] However, the absolute number of patients with MK decreased during the COVID-19 pandemic, as reported in several studies.[2,4,6,7] On the one hand, the authors raised concerns about the whereabouts of patients in need of urgent ophthalmologic care.[2,4,6,7] On the other hand, it was suggested that the decrease could be due to behavioral changes including decreased exposure to known risk factors, such as contact lens (CL) wear and ocular trauma, and increased hand hygiene.[4,6,8] In a national survey, adherence to the four NPIs imposed by the Dutch government was reported to be 61–100% in April 2020.[9] Power et al described that the outcome for suspected MK cases during the COVID-19 lockdown in two Dublin-based centers was potentially poorer than in the two pre-pandemic years, based on lower visual improvement and higher surgical intervention rate.[6] Suggested explanations were delays in presentation and deviations from standard care, such as a higher admission threshold and fewer patients treated with fortified antibiotics.[6]

During the "intelligent lockdown", cornea specialists working at the REH noted a marked decrease in the number of patients with MK, especially in the number of patients admitted for severe MK. The REH serves as an ophthalmologic tertiary referral center, mainly for the southwest region and to a lesser extent for the rest of the Netherlands. During the COVID-19 pandemic, treatment protocols for MK at the REH and on national level have not been adjusted, and hospital admissions for severe ophthalmologic conditions were still possible at the REH.

We therefore hypothesized that the observed decrease in MK patients at the REH could be explained by an actual decrease in patients with MK in the referral region of the REH due to less CL wear and improved hand hygiene. Although it remains uncertain whether microorganisms responsible for MK originally stem from hands, poor hand hygiene has been reported as a risk factor for MK acquisition in CL wearers.[10–12] We believe there could be a role for the out-of-hospital use of alcohol-based hand rubs, which became common during the COVID-19 pandemic. Besides, we questioned if there would be a sustained effect of NPIs on the number of MK patients after official measures were no longer in place. The main aim of this single-center study was to describe the number of patients presenting and admitted with MK at the REH before, during and after the COVID-19 pandemic, and retrospectively compare patient characteristics. We further compared self-reported CL wear and hand hygiene habits just prior to and during the COVID-19 pandemic in a large convenient sample of CL wearers.

Materials and Methods

Clinical Study

Study Setting

This single-center study was conducted at the REH, a large ophthalmologic tertiary referral center in Rotterdam, the Netherlands, that is open to patients referred by general practitioners, optometrists and ophthalmologists working in other hospitals, but does not provide "walk-in" specialist care. In 2023, 127,072 outpatient visits and 13,080 eye surgeries were conducted, covering a significant part of ophthalmologic secondary and tertiary care for the whole country.[13] Patients with ophthalmologic emergencies are primarily seen by residents, who are supervised by a general ophthalmologist, and by a cornea specialist in every case of severe corneal disease.

Study Period

Retrospectively, all patients presenting with MK to the REH during three distinct periods were included, based on ICD-10 codes. The main study period of interest, during which the most stringent NPIs were in place, was 9 March–15 June 2020 ("COVID"). During this period, routine consultations at the REH were cancelled, but the emergency department remained open for urgent ophthalmologic care, even for patients with proven or suspected COVID-19 infection. Two "pre-COVID" and "post-COVID" periods were defined, during the same time of the year, in order to

avoid seasonal effects on the occurrence of MK. The "pre-COVID" periods were 9 March–15 June 2018 and 9 March–15 June 2019. The "post-COVID" periods were 9 March–15 June 2022 and 9 March–15 June 2023. The period of 9 March–15 June 2021 was not included because of heterogeneity of COVID-19 measures during that pandemic year.

Microbiological Diagnostic Procedures

During all study periods, the hospital guideline for microbiological diagnostics in cases of suspected MK included a corneal smear with an eSwab (COPAN, USA) for infiltrates >1 mm, after which plating for culture was performed at the microbiological laboratory of the Maasstad Hospital (Rotterdam, the Netherlands), and the eSwab liquid was used for polymerase chain reaction (PCR) (NeumoDX, Qiagen, Germany).

Inclusion and Exclusion Criteria

An initial query for patients with newly registered ICD-codes H16.0, H16.2, H16.3 and H16.9 in the hospital information system was performed on 10 August 2023, followed by a manual selection step based on clinical diagnosis. A case with MK was defined as a patient presenting at the emergency care department with presumed or confirmed bacterial, fungal or parasitic keratitis. Patients with herpetic or other viral keratitis were excluded, as well as patients with immune stromal keratitis, marginal keratitis, allergic keratoconjunctivitis, punctate keratitis and corneal erosions, as these conditions had either less visual impact than MK or were not expected to be influenced by NPIs.

Patient Characteristics

Electronic patient files were searched to retrieve the following information on patient demographics and the MK episode: sex, age and residential postal code at first presentation, referring physician, date of symptom onset, date of presentation at the REH, relevant underlying systemic and ocular comorbidities (adapted from the list published by Butt et al[3] and shown in Supplementary Table 1), reported trauma related to the disease episode, recent or current CL use, visual acuity in Snellen decimals at first presentation, laboratory results (culture and/or PCR), actual hospital admission and admission indication, surgical intervention, date of last visit and visual acuity in Snellen decimals at last visit. Presentation delay was defined as the number of days between start of symptoms and first presentation at the REH and converted to a dichotomous variable based on the median of our complete study sample and the median found in the literature.[3] Follow-up was defined as the number of days between the first presentation and the last visit at the REH. Distance to REH was measured as the crow flies in kilometers between postal codes of the patient's home address and the REH. According to the hospital protocol, admission indication was a central corneal ulcer or a peripheral ulcer of >3 mm, and was assessed by the first and last author based on clinical description of the keratitis in the patient file and on medical photos if available.

Online Survey Among CL Wearers

An online cross-sectional survey among CL wearers was integrated in a retrospective multi-center case-control study that was performed by our study group in collaboration with the Dutch National Institute of Public Health and the Environment (RIVM) and several academic hospitals in the Netherlands (*manuscript in preparation*). For this case-control study, CL wearers of 16 years and older were recruited as controls through the official social media account of the RIVM in June–July 2020. Controls completed an online questionnaire pertaining to, among other topics, CL habits and hygiene practices in February 2020. As a final question, controls were requested to complete some additional questions about their overall compliance to the NPI's implemented during the COVID-19 pandemic, CL habits and hygiene practices in the month April 2020.

Statistics

Linear variables were presented with median and interquartile range (IQR); categorical variables as numbers (n) and proportions of the available sample in percentages (%). Comparisons were made within the pre-COVID and post-COVID groups before combining them, and subsequently between the pre-COVID and COVID groups, and between the pre-COVID and post-COVID groups. The Mann–Whitney *U*-test was used to compare linear variables. The Fisher's Exact test or Freeman-Halton extension of the Fisher's Exact test were used to compare categorical variables.

For the analysis of paired data from the online survey, the McNemar test was used for dichotomous variables and the Wilcoxon Signed Rank Test for ordinal and linear variables. All analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). Missing values and the answer category "I do not know" were excluded for analyses. Two-sided tests were done, considering a p-value smaller than 0.05 to be statistically significant.

Ethics

The retrospective clinical study has been exempted from requiring ethical approval after institutional review by the Scientific Research Committee at the REH. The case-control study, of which a selection of variables on CL wear and general hygiene was used from the responding controls, has been exempted from requiring ethical approval after review by an advisory committee at the RIVM. Both study components were compliant with the Declaration of Helsinki, and the data accessed complied with relevant data protection and privacy regulations.

Results

Clinical Study

Seventy-nine patients presented to the REH with a new episode of microbial keratitis in 2018, 69 in 2019, 41 in 2020, 60 in 2022 and 52 in 2023 (Figure 1). In the pre-COVID within-group analysis, comparing 2018 and 2019, no significant differences were found for clinical characteristics, proportion of microbiological diagnostics performed and number of actual and indicated admissions (Supplementary Table 2). In the post-COVID within-group analysis, comparing 2022 and 2023, two significant differences were encountered. The proportion of patients with active ocular surface disease was 22% in 2022 and 6% in 2023 (p-value = 0.028), and the proportion of patients with associated trauma was 3% in 2022 and 19% in 2023 (p-value = 0.012), while all other variables did not differ. The impact of these two variables on the homogeneity of the groups was considered small enough to justify combining the two post-COVID years.

Clinical Characteristics

The median age of MK patients at presentation was 42 years pre-COVID, 53 years during COVID and 44 years post-COVID (Table 1). The difference between pre-COVID and COVID was not significant (p-value = 0.078). The majority of patients were female, representing 60% in both pre-COVID and post-COVID groups, and 68% in the COVID group. There was a significant shift in the distribution of patients by referral status when comparing the pre-COVID group with the COVID group (p-value = 0.002). The proportion of patients referred by an ophthalmologist working in another center was 27% pre-COVID and 5% during COVID. The referral status was not significantly different when comparing pre-COVID with post-COVID (p-value = 0.362).

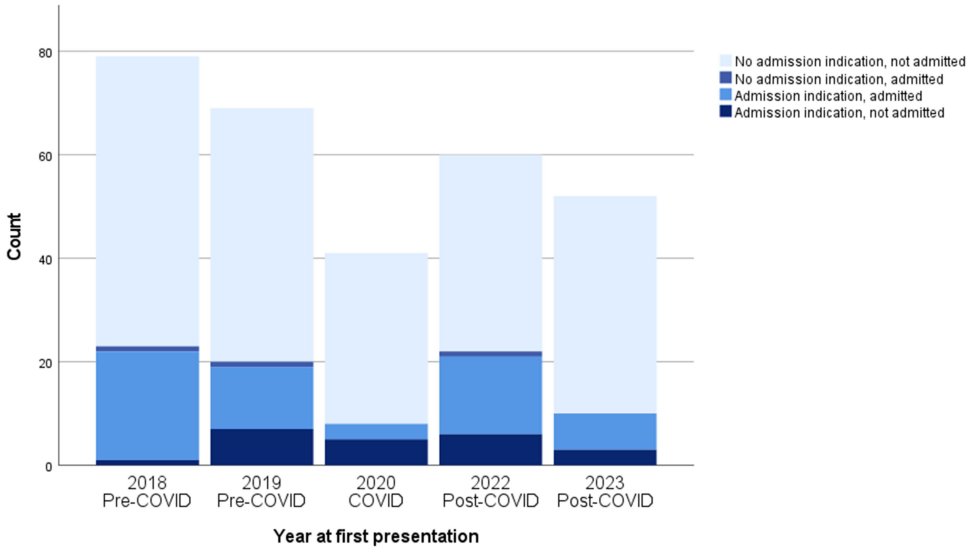

Figure 1 Number and admission status of patients with microbial keratitis presenting per year to the Rotterdam Eye Hospital.

Table 1 Clinical Characteristics of Patients With Microbial Keratitis Presenting to the Rotterdam Eye Hospital

	Pre-COVID (n = 148)	COVID (n = 41)	Pre-COVID - COVID P-value	Post-COVID (n = 112)	Pre-COVID - Post-COVID P-value
Age at presentation in years, median (IQR)	42 (29–58)	53 (35–62)	0.078	44 (30.5–60)	0.532
Female sex, n (%)	89 (60)	28 (68)	0.369	67 (60)	1.000
Method of referral, n (%)			**0.002**		0.362
- General practitioner or optometrist	88 (60)	29 (71)		62 (55)	
- Ophthalmologist elsewhere	40 (27)	2 (5)		34 (30)	
- Known REH patient	15 (10)	10 (24)		16 (14)	
- Other	3 (2)	0 (0)		0 (0)	
○ Self-referral	2 (1)				
○ Non-ophthalmologic specialist	1 (1)				
Missing, n *(%)*	*2 (1)*				
Distance to REH in kilometers, median (IQR)	8.0 (3.4–17.6)	9.2 (4.5–12.1)	0.823	8.8 (3.9–18.8)	0.581
Presentation delay of ≥4 days, n (%)	75 (54)	15 (38)	0.106	58 (53)	0.899
Not applicable, n (%)	*5 (3)*	*1 (2)*		*2 (2)*	
Missing, n *(%)*	*3 (2)*				
Systemic condition, n (%)					
- Diabetes mellitus	10 (7)	3 (7)	1.000	8 (7)	1.000
- Rheumatoid arthritis	2 (1)	1 (2)	0.522	3 (3)	0.655
- Systemic immune suppression (including for rheumatoid arthritis)	4 (3)	2 (5)	0.612	5 (5)	0.505
Active ocular surface disease, n (%)	27 (18)	11 (27)	0.271	16 (14)	0.501
Previous keratitis, n (%)	18 (12)	9 (22)	0.131	24 (21)	0.060
Previous surgery, n (%)	15 (10)	4 (10)	1.000	8 (7)	0.510
Associated trauma, n (%)	20 (14)	2 (5)	0.171	12 (11)	0.569
Contact lens wear, n (%)	103 (70)	27 (66)	0.704	79 (71)	0.892
Visual acuity at presentation ≤0.25 Snellen decimals, n (%)*	56 (40)	10 (28)	0.247	53 (50)	0.155
Impossible to determine, n *(%)*	*1 (1)*	*1 (2)*		*1 (1)*	
Not determined, n *(%)*	*6 (4)*	*4 (10)*		*4 (4)*	
Bilateral keratitis, n (%)	4 (3)	0 (0)	0.578	3 (3)	1.000

Notes: P-value <0.05 is highlighted in bold. Missing data are presented in italics. * Visual acuity measurement of 25% of CL wearers was without any correction.
Abbreviations: IQR, interquartile range; REH, Rotterdam Eye Hospital.

The median distance from patients' home to the REH was 8.0 km pre-COVID, 9.2 km during COVID and 8.8 km post-COVID. The proportion of patients presenting at least 4 days after MK symptom onset was 54% pre-COVID, 38% during COVID and 53% post-COVID. The difference between pre-COVID and COVID was not significant (p-value = 0.106). No significant differences were found for systemic comorbidities or for ocular comorbidities. The majority of MK patients were CL wearers: 70% pre-COVID, 66% during COVID and 71% post-COVID. The proportion of patients presenting with a visual acuity of ≤0.25 Snellen decimals was 40% pre-COVID, 28% during COVID and 50% post-COVID. The differences between pre-COVID and COVID (p-value = 0.247) and between pre-COVID and post-COVID (p-value = 0.155) were not statistically significant. A small number of patients were presented with bilateral keratitis: 4 pre-COVID, none during COVID and 3 post-COVID.

Microbiological Results

In all study periods, microbiological diagnostics were performed in the majority of MK patients: 78% pre-COVID, 78% during COVID and 72% post-COVID (Table 2). There were no differences in the proportion of positive bacterial, fungal and *Acanthamoeba* results or negative results during the three study periods. When looking into more detail at the most

Table 2 Microbiological Results

	Pre-COVID n (%)	COVID n (%)	Pre-COVID - COVID P-value	Post-COVID n (%)	Pre-COVID - Post-COVID P-value
Microbiological diagnostics performed	115/148 (78)	32/41 (78)	1.000	81/112 (72)	0.383
Positive:	53/115 (46)	9/32 (28)	0.073	32/81 (40)	0.383
- Bacterial	41/115 (36)	7/32 (22)	0.201	27/81 (33)	0.763
- Fungal	3/115 (3)	1/32 (3)	1.000	2/81 (3)	1.000
- *Acanthamoeba*	9/115 (8)	1/32 (3)	0.462	3/81 (4)	0.366
Bacterial cultures in detail					
Gram classification			0.429		0.075
- Gram-positive	21/41 (51)	5/7 (71)		7/27 (26)	
- Gram-negative	20/41 (49)	2/7 (29)		19/27 (70)	
- Other	0/41 (0)	0/7 (0)		1/27 (4)*	
Most frequent pathogens					
- *Pseudomonas aeruginosa*	11/41 (27)	0/7 (0)	0.179	19/27 (70)	**<0.001**
- *Staphylococcus aureus*	14/41 (34)	0/7 (0)	0.090	4/27 (15)	0.097
- *Moraxella* species	4/41 (10)	1/7 (14)	1.000	0/27 (0)	0.146

Notes: P-value <0.05 is highlighted in bold. * Both gram+ and gram-; excluded for the analysis.

frequently isolated pathogens, a higher proportion of *Pseudomonas aeruginosa (P. aeruginosa)* isolates was found post-COVID (70%) compared to pre-COVID (27%) (p-value < 0.001). No *P. aeruginosa* and *Staphylococcus aureus (S. aureus)* were isolated during COVID.

Hospital Admissions, Surgical Interventions and Visual Outcome

During COVID, 3 cases (7%) were admitted, compared to 35 (24%) pre-COVID and 23 (21%) post-COVID (Table 3). The difference in admission rates between pre-COVID and COVID was statistically significant (p-value = 0.026). The proportion of patients with an admission indication did not differ and was 28% pre-COVID and 20% during COVID (p-value = 0.322), and 28% post-COVID. Few MK patients in all study groups underwent a surgical intervention: 6 (4%) pre-COVID, 2 (5%) during COVID and 5 (5%) post-COVID. Evisceration was performed in 3 cases: 1 during COVID (2%) and 2 post-COVID (2%). There was no significant difference in the proportion of patients with a final visual acuity of ≤0.25 Snellen decimals. The median clinical follow-up duration was 24 days (IQR 8–77) pre-COVID, 25 days (IQR 7–43) during COVID and 21 days (IQR 7–82) post-COVID.

Online Survey Among CL Wearers

From a total of 1,111 respondents to the control questionnaire in June–July 2020, 1,020 (92%) reported being CL wearers and being 16 years or older in February 2020. Of these, 791 (78%) answered questions on CL habits and hygiene practices for the recall month of April 2020. These so-called COVID-respondents did not differ in median age and sex from non-COVID-respondents. The median age was 40 years (IQR 31–51) for COVID-respondents and 37 years (IQR 28–51) for non-COVID-respondents (p-value = 0.054). The proportion of females was 82% in COVID-respondents and 80% in non-COVID-respondents (p-value = 0.563). Of the COVID-respondents, 774 (98%) said to wear CLs in April 2020 (Table 4), of which the majority (60%) wore soft daily reusable lenses (Figure 2). Full compliance to COVID-19 NPIs was reported by 68% of COVID-respondents, while 30% were partially compliant and 2% did not adhere to the COVID-19 NPIs. The number of days per week on which CLs were worn was statistically lower in April 2020 compared to February 2020 (p-value < 0.001). Seventy-five percent of COVID-respondents reported daily CL wear in April 2020 compared to 82% in February 2020. The median daily hours of CL wear was 15 (IQR 12–16) in February 2020 and 14 (IQR 12–16) in April 2020, which was a statistically significant difference (p-value < 0.001). Hand washing before CL insertion and removal and hand disinfection was reported significantly more often in April 2020

Table 3 Hospital Admissions, Surgical Interventions and Visual Outcome

	Pre-COVID (n = 148)	COVID (n = 41)	Pre-COVID - COVID P-value	Post-COVID (n = 112)	Pre-COVID - Post-COVID P-value
Hospital admissions, n (%)					
- Actual admission	35 (24)	3 (7)	**0.026**	23 (21)	0.652
- Admission indication	41 (28)	8 (20)	0.322	31 (28)	1.000
- Admission indication, not admitted	6 (4)	5 (12)	0.063	8 (7)	0.406
Surgical interventions, n (%)	6 (4)	2 (5)	0.685	5 (5)	1.000
- Penetrating keratoplasty	2 (1)	1* (2)		2 (2)	
- Evisceration	0 (0)	1 (2)		2** (2)	
- Corneal biopsy	2 (1)	0 (0)		1 (1)	
- Botox for ptosis induction	1 (1)	0 (0)		0 (0)	
- Phototherapeutic keratectomy	1 (1)	0 (0)		0 (0)	
Final visual acuity of ≤ 0.25 Snellen decimals, n (%)	26 (18)	6 (15)	1.000	19 (17)	0.865
Not determined, n *(%)*	*10 (7)*	*2 (5)*		*21 (19)*	
Impossible to determine, n *(%)*	*1 (1)*	*1 (2)*		*1 (1)*	
Lost to follow-up, n *(%)*	*6 (4)*	*5 (12)*		*2 (2)*	
Follow-up in days, median (IQR)	24 (8–77)	25 (7–43)	0.335	20.5 (7–82)	0.736

Notes: P-value <0.05 is highlighted in bold. Missing data are presented in italics. * This patient first underwent UV crosslinking. ** One of these patients first underwent penetrating keratoplasty.
Abbreviation: IQR, interquartile range.

Table 4 Contact Lens Wear and Hand Hygiene Characteristics of 791 Contact Lens Users in February and April 2020

	February 2020	April 2020	P-value
CL wear, n (%)	791 (100)	774 (98)	**<0.001**
CL wear - number of days per week, n (%)			**<0.001**
- <1x per week	1 (<1)	11 (1)	
- 1–2 days per week	13 (2)	32 (4)	
- 3–4 days per week	32 (4)	51 (6)	
- 5–6 days per week	93 (12)	95 (12)	
- Every day	652 (82)	595 (75)	
- I do not know	0 (0)	1 (<1)	
Missing, n *(%)*		*6 (1)*	
Number of ties, n *(%) = 667 (84%)*			
CL wear – number of hours per day, median (IQR)	15 (12–16)	14 (12–16)	**<0.001**
Missing, n *(%)*	*4 (1)*		
Number of ties, n *(%) = 546 (69%)*			
Hand washing before CL insertion, n (%)			**0.001**
- Never	54 (7)	43 (5)	
- Sometimes	103 (13)	106 (13)	
- Often	152 (19)	131 (17)	
- Always	481 (61)	501 (63)	
- I do not know	0 (0)	2 (<1)	
Missing, n *(%)*	*1 (<1)*	*8 (1)*	
Number of ties, n *(%) = 649 (82%)*			

(*Continued*)

https://doi.org/10.2147/OPTH.S512671

Table 4 (Continued).

	February 2020	April 2020	P-value
Hand washing before CL removal, n (%)			**<0.001**
- Never	100 (13)	81 (10)	
- Sometimes	167 (21)	146 (19)	
- Often	168 (21)	146 (19)	
- Always	356 (45)	410 (52)	
- I do not know	0 (0)	1 (<1)	
Missing, n *(%)*		*7 (1)*	
Number of ties, n *(%) = 636 (80%)*			
Hand disinfection, n (%)			**<0.001**
- Never	475 (60)	116 (15)	
- <1x per day	129 (16)	158 (20)	
- 1–2x per day	57 (7)	169 (21)	
- 3–4x per day	38 (5)	120 (15)	
- >4x per day	63 (8)	205 (26)	
- I do not know	27 (3)	15 (2)	
Missing, n *(%)*	*2 (<1)*	*8 (1)*	
Number of ties, n *(%) = 224 (28%)*			

Notes: P-values <0.05 are highlighted in bold. Missing data and number of ties are presented in italics.
Abbreviations: CL, contact lens; IQR, interquartile range.

compared to February 2020 (p-values, respectively, 0.001, < 0.001 and < 0.001). Seventy-six percent of COVID-respondents indicated that they had to renew their CLs in April 2020, which was not considered a problem for almost all of them (97%). A small percentage of COVID-respondents indicated that they changed their CL mark or type (2%) or CL solution mark or type (4%) in April 2020.

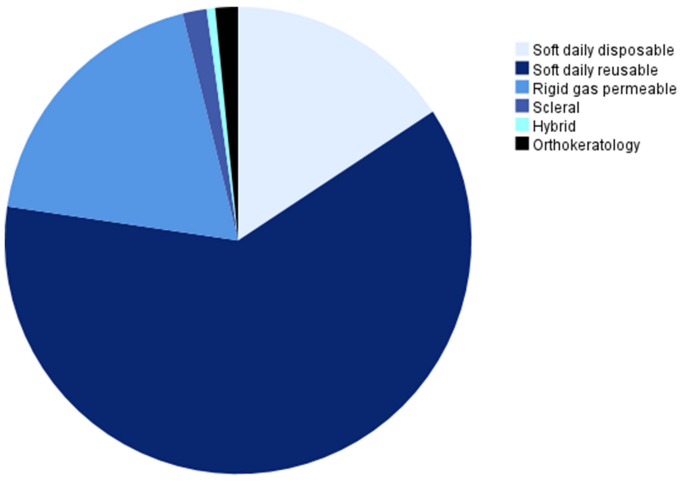

Figure 2 Contact lens type of individuals who reported wearing contact lenses during the COVID-19 pandemic.

Discussion

The COVID-19 pandemic and its associated lockdowns caused an immense disruption of societies and had particular effects on ophthalmologic emergency care.[2] At the Rotterdam Eye Hospital (REH), the largest ophthalmologic tertiary referral center in the Netherlands, we noted a striking decrease in hospital visits for microbial keratitis (MK) and a particularly low number of admissions for severe MK since the start of the COVID-19 pandemic. In the literature, concerns were raised about the whereabouts of patients in need of urgent care.[2,7,14] We hypothesized that there might have been a true overall decrease in MK incidence, with reduced contact lens (CL) use and improved hand hygiene, in particular with alcohol-based hand rubs, as a possible cause. We reasoned that the observed decrease could not be completely explained by reluctance to visit the hospital or lack of access to tertiary medical care as we would expect to see relatively more severe MK cases presenting late, and a higher proportion of cases admitted.

Our retrospective study showed that during the "intelligent lockdown" in 2020, the number of new MK episodes at the REH dropped to half of the average number of MK episodes in the same period of the two pre-COVID years combined. Several of our findings indicate that there was an actual decrease in MK incidence in the regional referral population of the REH. There was no difference in the proportion of MK patients with an admission indication, used as a proxy for severe keratitis, between the three study groups. Presentation delays were not longer and visual acuity at presentation was not worse for patients with MK during COVID. These findings are in line with studies published by other research groups. Butt et al described that presentation delays and visual acuities at presentation of MK cases did not differ when comparing study periods from three pre-COVID years with a COVID study period in a tertiary referral unit in Birmingham.[3] Also, in the study by Power et al, from two major ophthalmic hospitals in Dublin, the presenting visual acuity was higher in 2020 compared to 2018 and 2019.[6] The lower proportion of patients referred by ophthalmologists working in other hospitals during COVID potentially indicates that patients with severe MK were treated at secondary care level. However, severe MK patients from our referral region have always been sent to the REH with low threshold, because of less expertise and more logistical challenges for inpatient admissions in other centers. Additionally, the median distance between patient's home addresses and the REH was not significantly different, implying that the same referral region was served. We therefore assume that, just like at the REH, less cases of severe MK presented to ophthalmologists in other hospitals, but we encourage additional studies in primary and secondary care settings.

A possible explanation for a decreased incidence of MK during COVID would be less frequent CL wear.[3,4] It could be argued that the absence of cases caused by *P. aeruginosa*, the most common etiologic agent of CL related MK, underscores this argument.[15] However, our data provide two counterarguments. Firstly, in our online survey among CL wearers, 98% of respondents reported continuing to wear CLs in April 2020. In previous surveys, 67–72% of respondents reported wearing their CLs "less", without a detailed quantification of this statement.[16,17] Based on the data from our survey, CLs were worn significantly fewer days per week during COVID, but this applied only to 16% of respondents. Moreover, the median hours of CL wear per day in April 2020 were only 1 hour less than in February 2020. Secondly, the proportion of CL wearers in our study samples was comparable in the three groups. This implies that other behavioral adjustments, applying also to non-CL wearers, were of greater importance. In a cross-sectional online survey by the RIVM and Dutch public health services, the compliance to the hand hygiene-specific NPIs during three study periods in April and May 2020 was examined: respondents reported thorough hand washing in 48–61%, coughing and sneezing in the elbow in 71%, use of paper towels in 66–73% and no more hand shaking in 99–100%.[9] Our survey data show that CL wearers reported performing the following hygiene measures more frequently during COVID: hand washing before CL insertion, hand washing before CL removal and the use of hand disinfection products. The proportion of respondents that never used hand disinfection products was 60% in February and 15% in April. According to Statista Market Insights, the market share for hand disinfection products increased tremendously in 2020, with an estimated quintupling of revenues in Central & Western Europe compared to 2018 and 2019.[18] We assume that also non-CL wearers increased the use of hand disinfection products, which were found to be more effective in reducing the bacterial load on hands than hand washing provided they contain 60–80% alcohol.[19] A reduction in the occurrence of both *P. aeruginosa* and *S. aureus*, as was evident in our study, is generally regarded as an indicator of effective disinfection.[20,21] These microorganisms are not typically part of the normal conjunctival microbiota, and when present they are likely to have been introduced through

contaminated hands.[19] We therefore believe that the complete absence of these usual microbiological suspects of MK, *P. aeruginosa* and *S. aureus*, during COVID could be a result of the improvements in hand hygiene. In a systematic review on the impact of the COVID-19 pandemic on multidrug resistant pathogens, a decrease in the number of carbapenem-resistant *P. aeruginosa* infections, despite the increased use of carbapenems, was also attributed to hand and environmental hygiene in intensive care units.[22]

Previous studies on MK during the COVID-19 pandemic showed inconsistent findings on the number of cases caused by *P. aeruginosa*. While earlier-mentioned studies from Ireland and the UK confirmed the absence of *P. aeruginosa* during COVID, data from Portugal suggested an increase in *Pseudomonas* keratitis, and a recent publication from Mexico showed no difference when comparing COVID with pre-COVID, but noted a decrease in MK caused by *P. aeruginosa* post-COVID.[3,6,23,24] Besides geographical differences and different NPI's imposed during the COVID-19 pandemic, a possible explanation for the variation could be the extended time periods that were assigned to the COVID-groups in the studies from Portugal (March 2020-October 2021) and Mexico (January 2020-December 2022). The reason for the remarkable post-COVID increase in MK caused by *P. aeruginosa* in our study was not apparent, especially because all other variables did not differ from pre-COVID, underlining the need for additional studies.

Both the retrospective study and the online survey concerned a large study population. We included all patients with MK in the selected time frames, including cases that did not undergo microbiological diagnostics. The time frames were selected carefully, including only the true "intelligent lockdown" months in the COVID group, and we were able to make a comparison with a post-COVID time frame in which society largely returned to normal. However, the study design was retrospective and poses several limitations. Firstly, there is a possibility that we did not capture all MK cases, because of incorrect registration of ICD code at the time of patient presentation, although the registration of the diagnostic code is an important part of our treatment registration process for reimbursement by the health insurance companies. Secondly, we did not have information on the total number of visits to the REH emergency department, nor on the exact total number of CL wearers in the referral region. Thirdly, the possibility of other confounding factors could not be excluded. Regarding the survey, a major drawback is the possible recall bias. Because the request to participate was sent out during the COVID-19 pandemic, while we were primarily interested in CL and hygiene-related habits in the normal situation, there is a time difference of 4–5 months between the moment of participation and the recall period. This also induced a relatively high risk of response bias for the questions about CL habit changes in April 2020, because we expect that the majority of people that responded were still wearing CLs in June-July 2020 and did not stop wearing CLs when COVID-19 arrived. The high proportion of female respondents also highlights the potential of response bias. Lastly, there was unfortunately no possibility to repeat the survey in the time period post-COVID.

In our retrospective study, fewer patients with MK presented to the REH during the COVID-19 pandemic than in the two years before. We found no evidence suggesting that MK patients faced barriers to accessing hospital care, as presentation delays were not longer and cases were not more severe. The decreased incidence of MK did not appear to be attributable to a decrease in CL wear. Changing hand hygiene practices, including the use of alcohol-based hand rubs, could have been of more importance, as was underscored by the absence of MK caused by transient microorganisms *P. aeruginosa* and *S. aureus*. It would be very interesting to set up a prospective study on the use of alcohol-based hand disinfection before CL handling, as we believe this may lower the incidence of CL associated MK. However, since the incidence is already very low, such a study would need large numbers of participants.[25] In conclusion, our data suggest that the incidence of MK decreased during the COVID-19 pandemic and there may be a role for improved hand hygiene, including alcohol-based hand disinfection.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Dutch Government. Coronavirus developments in 2020. Available from: https://www.rijksoverheid.nl/onderwerpen/coronavirus-tijdlijn/2020. Accessed November 6, 2024. Dutch.
2. Wickham L, Hay G, Hamilton R, et al. The impact of COVID policies on acute ophthalmology services-experiences from Moorfields Eye Hospital NHS Foundation Trust. *Eye*. 2020;34(7):1189–1192. doi:10.1038/s41433-020-0957-2

3. Butt GF, Recchioni A, Moussa G, et al. The impact of the COVID-19 pandemic on microbial keratitis presentation patterns. *PLoS One*. 2021;16(8): e0256240. doi:10.1371/journal.pone.0256240
4. Poyser A, Deol SS, Osman L, et al. Impact of COVID-19 pandemic and lockdown on eye emergencies. *Eur J Ophthalmol*. 2021;31(6):2894–2900. doi:10.1177/1120672120974944
5. Cabrera-Aguas M, Khoo P, Watson SL. Infectious keratitis: a review. *Clin Exp Ophthalmol*. 2022;50(5):543–562. doi:10.1111/ceo.14113
6. Power B, Donnelly A, Murphy C, Fulcher T, Power W. Presentation of infectious keratitis to ED during COVID-19 Lockdown. *J Ophthalmol*. 2021;2021:5514055. doi:10.1155/2021/5514055
7. Pellegrini M, Roda M, Lupardi E, Di Geronimo N, Giannaccare G, Schiavi C. The impact of COVID-19 pandemic on ophthalmological emergency department visits. *Acta Ophthalmol*. 2020;98(8):e1058–e1059. doi:10.1111/aos.14489
8. Dart JK, Stapleton F, Minassian D, Dart JKG. Contact lenses and other risk factors in microbial keratitis. *Lancet*. 1991;338(8768):650–653. doi:10.1016/0140-6736(91)91231-I
9. National Institute for Public Health and the Environment. Results of research into behavioral measures and well-being. Available from: https://www.rivm.nl/gedragsonderzoek/covid-19/gedragsmaatregelen/maatregelen-welbevinden. Accessed November 28, 2024. Dutch.
10. Lim CH, Carnt NA, Farook M, et al. Risk factors for contact lens-related microbial keratitis in Singapore. *Eye*. 2016;30(3):447–455. doi:10.1038/eye.2015.250
11. Stapleton F, Naduvilath T, Keay L, et al. Risk factors and causative organisms in microbial keratitis in daily disposable contact lens wear. *PLoS One*. 2017;12(8):e0181343. doi:10.1371/journal.pone.0181343
12. Fonn D, Jones L. Hand hygiene is linked to microbial keratitis and corneal inflammatory events. *Cont Lens Anterior Eye*. 2019;42(2):132–135. doi:10.1016/j.clae.2018.10.022
13. Rotterdam Eye Hospital. Management report 2023. Available from: https://www.oogziekenhuis.nl/system/files/inline/OZR%20Jaarverslag%202023_zonder_0.pdf. Accessed January 28, 2025.
14. Das AV, Chaurasia S, Joseph J, Murthy SI. Year one of COVID-19 pandemic in India: effect of lockdown and unlock on the presentation of patients with infective keratitis at a tertiary eye center. *Indian J Ophthalmol*. 2021;69(12):3779–3782. doi:10.4103/ijo.IJO_2449_21
15. Green M, Sara S, Hughes I, Apel A, Stapleton F. Trends in contact lens microbial keratitis 1999 to 2015: a retrospective clinical review. *Clin Exp Ophthalmol*. 2019;47(6):726–732. doi:10.1111/ceo.13484
16. Morgan PB. Contact lens wear during the COVID-19 pandemic. *Cont Lens Anterior Eye*. 2020;43(3):213. doi:10.1016/j.clae.2020.04.005
17. Vianya-Estopa M, Garcia-Porta N, Pinero DP, et al. Contact lens wear and care in Spain during the COVID-19 pandemic. *Cont Lens Anterior Eye*. 2021;44(5):101381. doi:10.1016/j.clae.2020.11.001
18. Statista. Market insights - OTC pharmaceuticals - hand sanitizer - Europe. Available from: https://www.statista.com/outlook/hmo/otc-pharmaceuticals/hand-sanitizer/europe. Accessed November 8, 2024.
19. World Health Organization. WHO Guidelines on Hand Hygiene in Health Care. 2009. Available from: https://www.who.int/publications/i/item/9789241597906. Accessed October 15, 2024.
20. Jain VM, Karibasappa GN, Dodamani AS, Prashanth VK, Mali GV. Comparative assessment of antimicrobial efficacy of different hand sanitizers: an in vitro study. *Dent Res J*. 2016;13(5):424–431. doi:10.4103/1735-3327.192283
21. Sommatis S, Capillo MC, Maccario C, et al. antimicrobial efficacy assessment and rheological investigation of two different hand sanitizers compared with the standard reference WHO formulation 1. *Gels*. 2023;9(2):108. doi:10.3390/gels9020108
22. Abubakar U, Al-Anazi M, Alanazi Z, Rodríguez-Baño J. Impact of COVID-19 pandemic on multidrug resistant gram positive and gram negative pathogens: a systematic review. *J Infect Public Health*. 2023;16(3):320–331. doi:10.1016/j.jiph.2022.12.022
23. Lima-Fontes M, Martinho-Dias D, Leuzinger-Dias M, et al. Microbiological profile of infectious keratitis during covid-19 pandemic. *Clin Ophthalmol*. 2023;17:535–543. doi:10.2147/OPTH.S395877
24. Haro-Morlett L, Vera-Duarte GR, Oliveros-Valdes F, et al. Effects of the COVID-19 pandemic on microbial keratitis: a 5-year comparative study. *Cornea*. Epub 2024 Oct 4. doi:10.1097/ICO.0000000000003720
25. Ting DSJ, Ho CS, Deshmukh R, Said DG, Dua HS. Infectious keratitis: an update on epidemiology, causative microorganisms, risk factors, and antimicrobial resistance. *Eye*. 2021;35(4):1084–1101. doi:10.1038/s41433-020-01339-3