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Increased photokeratitis during the coronavirus disease 2019 pandemic

Clinical and epidemiological features and preventive measures

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Abstract

An increased incidence of photokeratitis has occurred during the coronavirus disease 2019 (COVID-19) pandemic due to improper and unprotected use of ultraviolet lamps. Here, we summarize the clinical and epidemiological features of this increased incidence of photokeratitis and share advice in using health education to prevent it.

We collected data from patients diagnosed with photokeratitis from October 7, 2019 to December 1, 2019, and from February 17, 2020 to April 12, 2020, and compared the frequency of onset, site of ultraviolet radiation (UVR) exposure, reason for exposure, exposure time, and recovery time. We also implemented and evaluated multiple measures of public health education to prevent increased disease.

After the COVID-19 outbreak, the frequency of onset of photokeratitis increased significantly, especially among young women. The main reason for UVR exposure changed from welding to disinfection. The incidence sites varied, and the exposure time was longer. As a result, patients needed a longer time to recover. Positive health education was an useful and convenient measure to prevent the disease.

While the COVID-19 pandemic is ongoing, more attention should be paid to public health and implement positive measures to prevent photokeratitis.

Abbreviations: COVID-19 = the coronavirus disease 2019, UVR = ultraviolet radiation.

Keywords: the coronavirus disease 2019, disinfection lamp, health education photokeratitis, ultraviolet radiation

1. Introduction

Photokeratitis, first reported in 1859 by Charcot, is a common ophthalmic emergency or occupational injury caused by ultraviolet radiation (UVR). In a plateau, ocean, or snowy mountain, where sunlight is strong, the same damage may also occur; therefore, it is also referred to as solar ophthalmia or snow blindness.[1] The clinical syndrome presents with ocular pain, tearing, conjunctival chemosis, blepharospasm, and deterioration of vision, typically several hours after exposure.[2]

Photokeratitis results from acute high-dose or suprathreshold UVR.[3,4] The cornea, particularly the corneal epithelium, absorbs UVR predominantly in the range of 100 to 280 nm, acting as a major protective shield against UVR. The biological damage is mainly due to the generation of reactive oxygen species as a result of an imbalance between reactive oxygen species generation and antioxidant defense.[5,6]

Normally, welding workers, mountaineers, skiers, and beach recreationists are susceptible to photokeratitis.[2] In Suzhou, Jiangsu Province, China, located at a latitude of 31.3°, which is far from both the ocean and mountains, photokeratitis mainly affects welding workers, and most cases are sporadic.[7] However, the situation has changed since the introduction of the coronavirus disease 2019 (COVID-19).

The COVID-19 pandemic caused by SARS-CoV-2 has resulted in significant morbidity and mortality around the world and has resulted in great panic among people.[8,9] A tremendous need for disinfection has arisen not only in hospitals but also in homes, dormitories, workshops, storefronts, and other places due to fear of infection. To meet the need for disinfection, ordinary people have widely purchased and used ultraviolet lamps because of their effectiveness and simplicity.[10] However, improper and unprotected use of ultraviolet lamps leads to significantly increased photokeratitis.

When we noticed an increased incidence of photokeratitis, we took preventive measures, including health education and circulating informative articles online and via WeChat. After these public education measures, the frequency of onset gradually decreased. In this article, we summarize the clinical and

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epidemiological features of an episode of increased photokeratitis during the COVID-19 outbreak and share our experience in preventing it.

2. Methods

2.1. Patients

We collected data from patients diagnosed with photokeratitis at the First Affiliated Hospital of Soochow University, Suzhou, Jiangsu Province, China, between February 17, 2020 and April 12, 2020 (8 weeks), and reviewed cases of patients with photokeratitis treated at the same hospital between October 7, 2019 and December 1, 2019 (8 weeks) as the control group by checking their medical records and contacting them by telephone. The data collected included sex, age, occupation, and the time and course of exposure to UVR. The author who collected and analyzed the data was unaware of the grouping. Ethical approval was obtained from the ethics committee of the First Affiliated Hospital of Soochow University (No. 20200043). Informed consent was obtained from all patients.

2.2. Diagnosis, treatment, and health education

A diagnosis was made according to each patient's history, including exposure to UVR 24 hours before onset; symptoms that included unilateral eye pain, photophobia, and tearing; conjunctival hyperemia and corneal epithelium shedding seen on examination with a slit lamp; and positive punctate fluorescent staining.

To promote corneal epithelial healing and prevent infection, patients were treated with recombinant bovine basic fibroblast growth factor eye drops (21,000 IU/5 mL, YiSheng Co., Zhuhai, China) 4 times per day, ofloxacin ointment (3 mg/L g, Santan Co., Osaka, Japan) 2 times per day, cold compresses, and sufficient rest.[2,11] Daily follow-up was required to observe the corneal condition until complete epithelial healing occurred, which took no >3 days.

Immediately following the upward trend of photokeratitis in the first 2 weeks of the 2020 time period, we carried out health education, informing people that they should leave the room to avoid UVR when the ultraviolet disinfection equipment was working, that the recommended disinfection time was about 30 minutes, and that the room should be adequately ventilated after disinfection. Education also included the pathology and treatment of photokeratitis and other issues. We explained these facts to patients at their hospital visits and asked them to tell their family and friends. We published related articles on our hospital website and the social networking platform WeChat, and disseminated these articles via doctors' WeChat friend circles. We also distributed educational material in large factories and communities (Fig. 1).

2.3. Statistical analysis

Results are presented as means ± SD and were analyzed statistically using SPSS 20.0 (IBM, Armonk, NY). A chi-squared test was used to compare the frequency of onset, percentage of symptom relief, and epithelial healing. Analysis of variance was performed to compare exposure time, time from exposure to symptoms, and visual acuity. Differences were considered significant when $P < .05$.

3. Results

3.1. Demographic information

According to the hospital information system, 31 patients were diagnosed with photokeratitis between October 7, 2019 and December 1, 2019, compared with 109 patients between February 17, 2020 and April 12, 2020. Of 31 patients diagnosed before the COVID-19 outbreak, 22 patients received a complete and effective telephone review. Before the COVID-19 outbreak, the patients consisted of 23 men and 8 women, aged 22 to 58 years old, with an average age of 37.1 years. After the COVID-19 outbreak, the patients consisted of 55 men and 54 women, aged 21 to 54 years old, with an average age of 32.1 years (Table 1). Overall, more young women were diagnosed in the later period. Most patients complained of eye pain, while others complained of epiphora, blurry vision, and other symptoms.

3.2. Frequency of onset

We defined observation periods as lasting 2 weeks, in accordance with the 14-day SARS-CoV-2 latency period. Before the COVID-19 outbreak, there were 7, 9, 7, and 8 patients in the first, second, third, and fourth 2-week periods, respectively, showing little difference. After the COVID-19 outbreak, the frequency of onset increased significantly, with 25 patients diagnosed in the first 2 weeks and a peak of 38 patients in the second 2-week period. After the implementation of health education, the number of patients decreased gradually, with 27 patients presenting in the third 2-week period and 19 patients in the fourth period, which was still higher than before the COVID-19 outbreak (Fig. 2).

3.3. Comparison of incidence

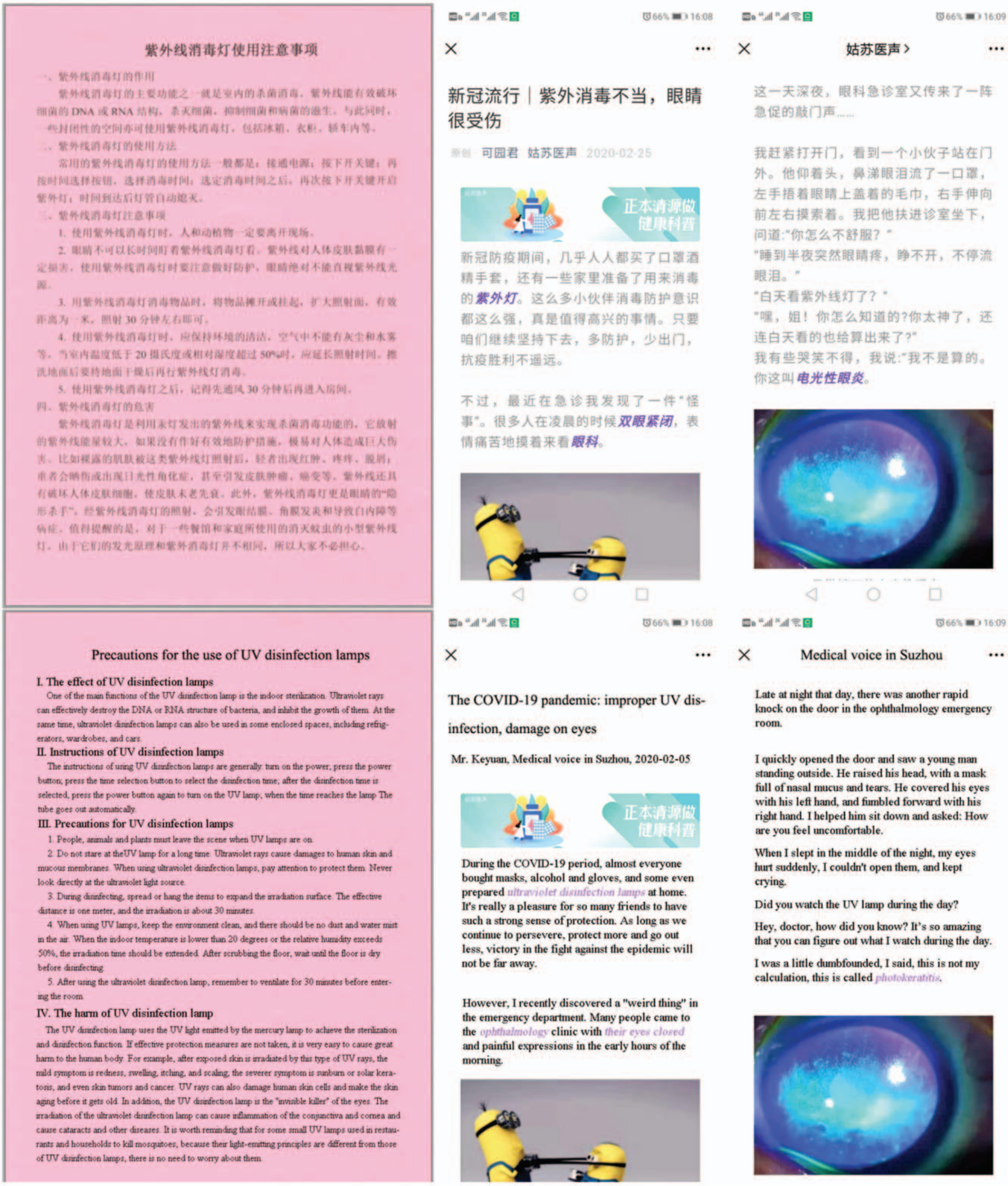
There was a strong difference in the course of exposure to UVR before and after the COVID-19 outbreak, which was the main reason for the increased incidence. Before the COVID-19 outbreak, only 9% of cases were clustered, and this percentage increased to 30% after the COVID-19 outbreak (Fig. 3A). Before the COVID-19 outbreak, welding was the main reason for UVR exposure (approximately 68%), while disinfection was the main reason following the COVID-19 outbreak (approximately 57%) (Fig. 3B). Before the COVID-19 outbreak, UVR exposure occurred mainly at construction sites (approximately 64%), but it occurred at construction sites, workshops, storefronts, and homes after the COVID-19 outbreak (Fig. 3C).

3.4. Exposure duration

The duration of exposure to UVR is a key factor in corneal epithelial damage. Before the COVID-19 outbreak, there was little difference during the different observation periods; therefore, we averaged the exposure duration over 8 weeks (8.7 minutes). After the COVID-19 outbreak, the average exposure duration increased to 16.7 minutes ($P < .05$). Although the frequency of onset decreased in the third and fourth 2-week periods in the 2020 period, the exposure duration varied little among all periods ($P = .376$) (Fig. 4).

3.5. Clinical features

The time from exposure to symptoms ranged from 6 to 12 hours, with an average of 9.5 hours before the COVID-19 outbreak and


紫外线消毒灯使用注意事项

新冠流行｜紫外消毒不当，眼睛很受伤

原创 可园君 姑苏医声 2020-02-25

正本清源做 健康科普

新冠防疫期间，几乎人人都买了口罩酒精手套，还有一些家里准备了用来消毒的紫外灯。这么多小伙伴消毒防护意识都这么强，真是值得高兴的事情。只要咱们继续坚持下去，多防护，少出门，抗疫胜利不遥远。

不过，最近在急诊我发现了一件"怪事"。很多人在凌晨的时候双眼紧闭，表情痛苦地摸着来看眼科。

姑苏医声 >

这一天深夜，眼科急诊室又传来了一阵急促的敲门声……

我赶紧打开门，看到一个小伙子站在门外。他仰着头，鼻涕眼泪流了一口罩，左手捂着眼睛上盖着的毛巾，右手伸向前左右摸索着。我把他扶进诊室坐下，问道:"你怎么不舒服？"

"睡到半夜突然眼睛疼，睁不开，不停流眼泪。"

"白天看紫外线灯了？"

"嘿，姐！你怎么知道的?你太神了，还连白天看的也给算出来了?"

我有些哭笑不得，我说:"我不是算的。你这叫电光性眼炎。

Precautions for the use of UV disinfection lamps

I. The effect of UV disinfection lamps

One of the main functions of the UV disinfection lamp is the indoor sterilization. Ultraviolet rays can effectively destroy the DNA or RNA structure of bacteria, and inhibit the growth of them. At the same time, ultraviolet disinfection lamps can also be used in some enclosed spaces, including refrigerators, wardrobes, and cars.

II. Instructions of UV disinfection lamps

The instructions of using UV disinfection lamps are generally: turn on the power; press the power button; press the time selection button to select the disinfection time; after the disinfection time is selected, press the power button again to turn on the UV lamp; when the time reaches the lamp The tube goes out automatically.

III. Precautions for UV disinfection lamps

1. People, animals and plants must leave the scene when UV lamps are on.
2. Do not stare at theUV lamp for a long time. Ultraviolet rays cause damages to human skin and mucous membranes. When using ultraviolet disinfection lamps, pay attention to protect them. Never look directly at the ultraviolet light source.
3. During disinfecting, spread or hang the items to expand the irradiation surface. The effective distance is one meter, and the irradiation is about 30 minutes.
4. When using UV lamps, keep the environment clean, and there should be no dust and water mist in the air. When the indoor temperature is lower than 20 degrees or the relative humidity exceeds 50%, the irradiation time should be extended. After scrubbing the floor, wait until the floor is dry before disinfecting.
5. After using the ultraviolet disinfection lamp, remember to ventilate for 30 minutes before entering the room.

IV. The harm of UV disinfection lamp

The UV disinfection lamp uses the UV light emitted by the mercury lamp to achieve the sterilization and disinfection function. If effective protection measures are not taken, it is very easy to cause great harm to the human body. For example, after exposed skin is irradiated by this type of UV rays, the mild symptom is redness, swelling, itching, and scaling; the severer symptom is sunburn or solar keratosis, and even skin tumors and cancer. UV rays can also damage human skin cells and make the skin aging before it gets old. In addition, the UV disinfection lamp is the "invisible killer" of the eyes. The irradiation of the ultraviolet disinfection lamp can cause inflammation of the conjunctiva and cornea and cause cataracts and other diseases. It is worth reminding that for some small UV lamps used in restaurants and households to kill mosquitoes, because their light-emitting principles are different from those of UV disinfection lamps, there is no need to worry about them.

The COVID-19 pandemic: improper UV disinfection, damage on eyes

Mr. Keyuan, Medical voice in Suzhou, 2020-02-05

正本清源做 健康科普

During the COVID-19 period, almost everyone bought masks, alcohol and gloves, and some even prepared ultraviolet disinfection lamps at home. It's really a pleasure for so many friends to have such a strong sense of protection. As long as we continue to persevere, protect more and go out less, victory in the fight against the epidemic will not be far away.

However, I recently discovered a "weird thing" in the emergency department. Many people came to the ophthalmology clinic with their eyes closed and painful expressions in the early hours of the morning.

Medical voice in Suzhou

Late at night that day, there was another rapid knock on the door in the ophthalmology emergency room.

I quickly opened the door and saw a young man standing outside. He raised his head, with a mask full of nasal mucus and tears. He covered his eyes with his left hand, and fumbled forward with his right hand. I helped him sit down and asked: How are you feel uncomfortable.

When I slept in the middle of the night, my eyes hurt suddenly, I couldn't open them, and kept crying.

Did you watch the UV lamp during the day?

Hey, doctor, how did you know? It's so amazing that you can figure out what I watch during the day.

I was a little dumbfounded, I said, this is not my calculation, this is called photokeratitis.

Figure 1. Scanned copy of distributed leaflets and screenshot of WeChat article (above), the translated version (below).

9.2 hours after the COVID-19 outbreak, showing no statistical difference ($P = .549$, Fig. 5A). Patients complained of severe pain or burning sensation in unilateral eyes, difficulty in opening the eye, photophobia, tearing, and other symptoms. Typical photokeratitis presented as conjunctival hyperemia, corneal epithelium shedding, and positive punctate fluorescent staining (Fig. 5B and C). No large corneal epithelial defect, corneal stromal edema, corneal infection, or other serious keratopathy was observed in any patient.

3.6. Recovery

The average best-corrected visual acuity after photokeratitis was 0.23±0.07 logMAR and 0.25±0.08 logMAR before and after

Table 1

Patient characteristics.

	Total number	Sex (M/F)	Average age (age range)	Chief complaint		
				Pain	Epiphora	Blurry vision
Before the COVID-19 outbreak	31	23/8	37.1 (22–58)	24	3	2
After the COVID-19 outbreak	109	55/54	32.1 (21~54)	73	17	12

COVID-19 = the coronavirus disease 2019.

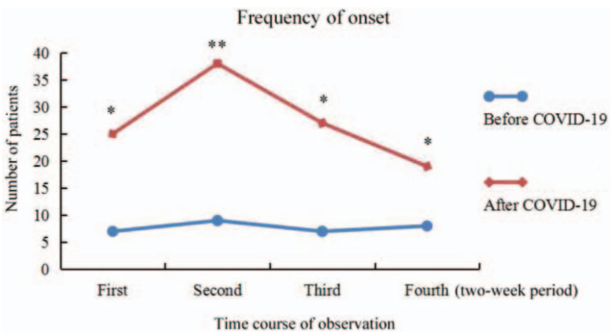


Figure 2. The frequency of onset before and after the COVID-19 outbreak. * $P<.05$, ** $P<.01$, the statistical difference of frequency in each period.

the COVID-19 outbreak, respectively, with no statistical difference ($P=.448$). By 72 hours after treatment, the average best-corrected visual acuity improved significantly to 0.04 ± 0.02 logMAR and 0.05 ± 0.02 logMAR (both $P<.01$ vs before treatment) before and after the COVID-19 outbreak, respectively. In addition, the improved visual acuity after treatment showed no statistical difference before and after the COVID-19 outbreak ($P=.753$, Fig. 6A).

After treatment, all patients were cured in a short time, and no complications were observed. Before the COVID-19 outbreak, 36% of patients experienced symptom relief within 6 hours, 77% within 12 hours, and 100% within 24 hours. This changed to 21% ($P<.05$) within 6 hours, 69% ($P=.388$) within 12 hours, and 96% ($P=.736$) within 24 hours after the COVID-19 outbreak (Fig. 6B), which was lower than before. Before the COVID-19 outbreak, the corneal epithelium healed in 41% of

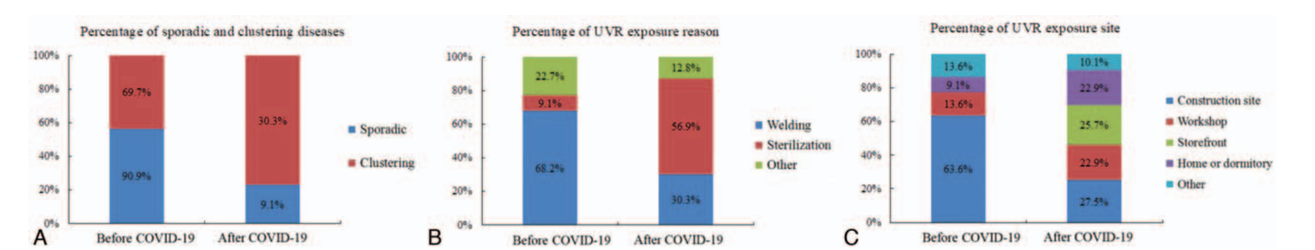


Figure 3. Structure of incidence. A: Percentages of sporadic and clustering diseases. B: Percentages of reasons for UVR exposure. C: Percentages of sites of UVR exposure. UVR = ultraviolet radiation.

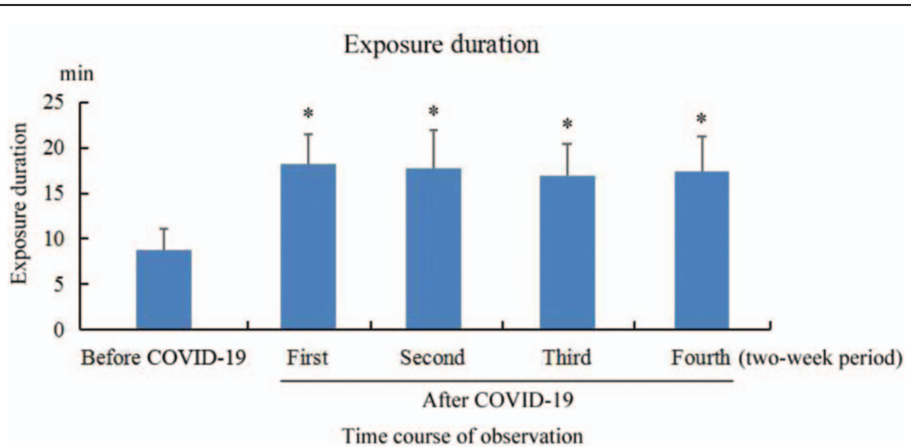


Figure 4. UVR exposure duration before and after the COVID-19 outbreak. * $P<.05$, statistical difference of UVR exposure duration in each period compared with that before the COVID-19 outbreak, there was no statistical difference of UVR exposure duration among the 4 periods after the COVID-19 outbreak. COVID-19 = the coronavirus disease 2019, UVR = ultraviolet radiation.

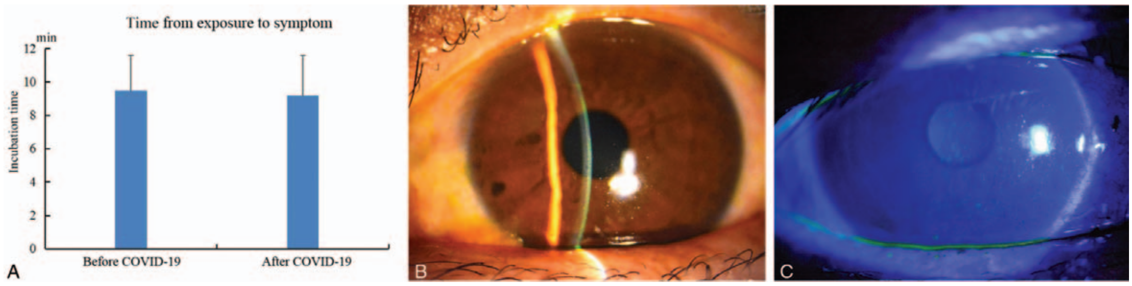


Figure 5. Clinical manifestation of photokeratitis. A: Average time from exposure to symptoms. There was no significant difference between before and after the COVID-19 outbreak. B: Typical slit-lamp image. C: Epithelial punctate fluorescent staining. COVID-19=the coronavirus disease 2019.

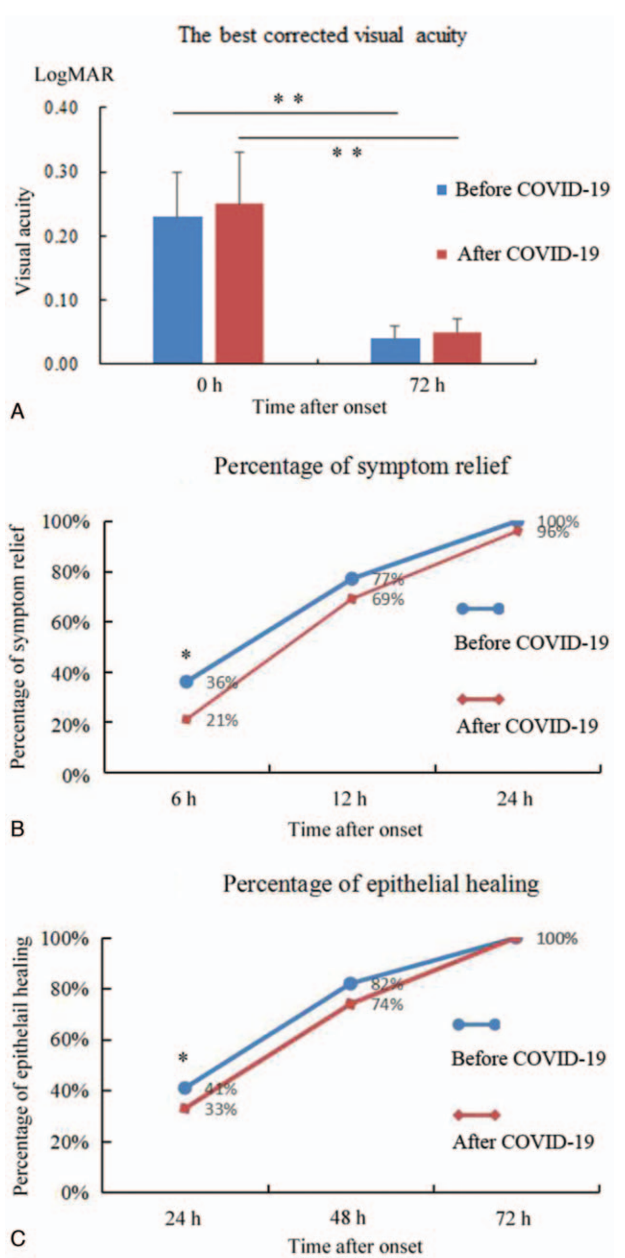


Figure 6. Recovery from photokeratitis. A: Best-corrected visual acuity before and after treatment. B: Percentage of symptom relief at different times. C: Percentage of epithelial healing at different times. * $P<.05$, ** $P<.01$, statistical difference of each data.

patients within 24 hours, 82% within 48 hours, and 100% within 72 hours. However, this changed to 33% ($P<.05$) within 24 hours, 74% ($P=.451$) within 48 hours, and 100% ($P=.924$) within 72 hours (Fig. 6C), which was also slower than before.

4. Discussion

Photokeratitis is not a complex disease and has a definite pathogeny and good prognosis. As economic development and protection for workers and travelers have progressed, the incidence has tended to decrease.[12] However, the sudden increase in this disease during the COVID-19 outbreak in Suzhou was unexpected, highlighting the importance of "simple" disease management and public health education.

Although COVID-19 had been reported as early as the end of December 2019, it did not draw public attention until January 20, 2020, which was also the Spring Festival holiday in China. The vacation was extended by the government, and people returned to work gradually in mid-February. Therefore, we chose February 17, 2020 as the beginning of the observation period. As the incubation period of COVID-19 is normally considered to be 14 days and many policies also depend on this time,[13] we chose 2 weeks as the observation period. On April 12, we stopped observation when we found that the frequency of onset substantially decreased. For the control group, we chose October 7, 2019 to December 1, 2019.

According to the results, there was an increase in young women suffering from photokeratitis, which was in accordance with the change in the susceptible population. Before the COVID-19 outbreak, patients with photokeratitis were mainly welding workers, who were mostly middle-aged men. After the COVID-19 outbreak, more assembly line workers and shop assistants, most of whom were young women, were affected by the disinfection of workshops and storefronts. The leading reason for UVR exposure also changed from welding to sterilization after the COVID-19 outbreak. The percentage of cases of UVR exposure at home, workshops, and storefronts was almost equal in the second period, indicating that improper and unprotected use of ultraviolet lamps was a common phenomenon, and publicity and education on this issue was necessary and urgent.

There is no large-scale epidemiological study on the incidence of photokeratitis because it is affected greatly by social development, employment structure, latitude, topography, and other factors. According to our hospital information system, the change in the number of photokeratitis cases in 1 month was not obvious, and most cases were sporadic before the COVID-19 outbreak. Photokeratitis caused by improper and unprotected use of ultraviolet lamps has also occurred in Hong Kong and the

United States.[10,14] A total of 7 patients were reported in a study from the United States, and the reasons, exposure times, and sites were similar to our results, indicating that more attention should be paid to this issue.

UVR can be divided into 3 bands: UVA at 320 to 400 nm, UVB at 290 to 320 nm, and UVC at 200 to 290 nm. Shorter UVR wavelengths have more energy and a greater potential for ocular damage.[15,16] For disinfection, most ultraviolet lamps on the market produce UVR at 200 to 280 nm, which is more dangerous to the eye. First, the corneal epithelium absorbs most UVR wavelengths because of its high protein and nucleic acid content. Then, oxidative photodegradation and production of reactive oxygen species are responsible for most damage in the course of photokeratitis.[17,18] Despite the potential danger, there has been no regulation or restriction for the production and sale of ultraviolet lamps, which also contributes to an increased incidence of photokeratitis.

UVR exposure time was recorded mainly based on descriptions from patients, and most patients remembered the exposure course. Although it was a subjective variable, we considered it meaningful because it reflected this fact. Most welding workers are aware of UVR dangers, and exposure in this population is mainly due to a lack of caution or inadequate protection, so the exposure duration is short. However, patients with eye damage due to ultraviolet lamps are not aware of UVR damage, and they may be in a UVR environment for a long time. To make matters worse, photokeratitis is typically characterized by a delay between exposure and the beginning of symptoms,[12,19] which further prevents people from leaving the UVR environment. Correspondingly, patients seen during the COVID-19 outbreak had a tendency toward delayed symptom relief and epithelial healing, which may be due to the longer UVR exposure and consequent damage.

Physicians should not only focus on diseases and patients but also on public health. At the very beginning of the period of increased incidence, when a few patients came to the hospital due to improper ultraviolet lamp use, we realized that more people may suffer the same problem. Therefore, we took measures to warn the public and explain how to safely use ultraviolet lamps. We asked every patient to talk about this issue to their family and colleagues, especially workshop supervisors and shopkeepers, to avoid the same problem. Our website articles and WeChat postings have been read cumulatively over one hundred thousand times. With our efforts, the frequency of onset began to decrease during the third 2-week period. Other doctors in Shanghai, Beijing, and other parts of China also performed the same measures during this period.

Some limitations of our study should be noted. First, some objective clinical information, such as intraocular pressure and corneal fluorescence staining score, were not evaluated. Second, this was a retrospective study with a small sample restricted to our hospital in Suzhou. A large sample over multiple locales is needed to verify the results of our study.

5. Conclusion

The unexpected increase in photokeratitis during the COVID-19 outbreak suggests the importance of paying close attention to public health. Health education and positive publicity proved to be effective and convenient measures to prevent such a situation.

Author contributions

Data curation: Jing Lou.
Formal analysis: Ye Ji.
Writing – original draft: YingMing Wang.
Writing – review & editing: ZhenYu Wang.

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