学 位 論 文 の 要 旨

氏名　杉原 一暢

学 位 論 文 名　One-year Ocular Safety Observation of Workers and Estimations of Microorganism Inactivation Efficacy in the Room Irradiated With 222-nm Far Ultraviolet-C Lamps

発 表 雑 誌 名（巻，初頁～終頁，年）　Photochemistry and Photobiology (**99(3)**, 967-974, 2023)

著 者 名　Kazunobu Sugihara, Sachiko Kaidzu, Masahiro Sasaki, Sho Ichioka, Yuji Takayanagi, Hiroshi Shimizu, Ichiya Sano, Katsunori Hara, Masaki Tanito

論 文 内 容 の 要 旨

INTRODUCTION

This study investigates the safety and microbial efficacy of 222-nm far-ultraviolet-C (Far-UVC) radiation, specifically for continuous room disinfection in clinical environments where human presence is common. Far-UVC light at 222 nm has emerged as a promising germicidal solution that, unlike traditional 254-nm UV-C radiation, is believed to minimize harm to human skin and eyes while maintaining strong antimicrobial effects. Given the rising demand for effective disinfection methods, particularly in healthcare settings, evaluating the safety and effectiveness of 222-nm Far-UVC light is crucial. This study was conducted over a 12-month period in the ophthalmology department at Shimane University Hospital, where two KrCl excimer lamps emitting 222-nm UV-C light were installed in an examination room. The study aimed to determine the potential ocular safety effects on healthcare personnel exposed to Far-UVC and to quantify the efficacy of 222-nm UV-C irradiation in reducing surface contamination by microorganisms.

MATERIALS AND METHODS

This study consists of two main sections: a human observational safety study and a microbial

inactivation efficacy study. Six ophthalmologists working in the UV-C irradiated room were recruited for the safety observation, which adhered to ethical guidelines under the Declaration of Helsinki and received Institutional Review Board (IRB) approval. The study protocol was approved by the Research Ethics Committee of Shimane University. These participants, who spent an average of 6.7 hours per week in the examination room, underwent regular eye examinations, including visual acuity tests, refractive error assessments, and slit-lamp examinations, to monitor potential adverse effects from UV exposure. Measurements were taken before the start of the study, at the end of the first day, and at one, three, six, and twelve months. For microbial inactivation tests, samples of *Staphylococcus aureus* and the φX174 bacteriophage were placed on trays positioned on various surfaces in the room. UV exposure cycles were set for 200 seconds "on" and 1600 seconds "off," providing cumulative irradiation of up to 7.5 mJ/cm^2. Statistical analysis involved mixed-effects regression models to assess ocular health data over time, while microbial inhibition rates were analyzed using one-way ANOVA.

RESULTS AND DISCUSSION

Throughout the 12-month observational period, no significant adverse effects were recorded among the participants. Visual acuity, refractive error, and corneal endothelial cell density remained stable across all subjects. Slit-lamp examinations showed no signs of photokeratitis, pterygium, cataracts, or eyelid abnormalities, confirming the ocular safety of long-term exposure to 222-nm UV-C at doses well within the threshold limit value (TLV) guidelines. One participant discontinued the study at six months; however, no adverse symptoms were reported by any participants during or after the study. The microbial inactivation results demonstrated substantial efficacy, with more than 90% inhibition of *S. aureus* and over 99% inhibition of φX174 phage in samples placed on irradiated surfaces. These results indicate that 222-nm Far-UVC has a significant disinfecting effect on bacteria and viruses present on surfaces within the exposure area. The inhibition rates varied between microorganisms, which may be attributed to differences in their structural and size-related characteristics, impacting UV-C penetration. These findings are consistent with prior research on the high sensitivity of bacteria and viruses to shorter wavelengths. Additionally, the participants' eyeglasses provided an extra level of protection against UV-C exposure, which may further reduce any potential ocular risks.

CONCLUSION

The findings from this study highlight the potential of 222-nm Far-UVC irradiation as an effective and safe disinfection method suitable for use in occupied clinical environments. Over a 12-month period, no ocular health issues were observed among healthcare workers, indicating that Far-UVC light at 222 nm, when used at appropriate dose limits, can be safely implemented for continuous room disinfection. The significant microbial inactivation achieved supports the utility of this technology in reducing surface

contamination in healthcare facilities, contributing to infection control efforts. Far-UVC light, with its demonstrated safety and effectiveness, may offer a viable alternative to traditional disinfection methods, particularly in settings requiring frequent human occupancy. Further studies could explore the applicability of Far-UVC for air disinfection and its integration with existing hospital protocols to enhance overall patient and staff safety.