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Far UV 222 nm Treatment of Corneal Ulcers

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Abstract

Purpose: The aim of this study was to investigate the efficacy of FAR 222 nm UV light in the treatment of apparently infected corneal ulcers.

Design: Patients with apparently infected corneal ulcers were offered the IRB approved protocol of FAR UV 222 nm UV light, in addition to standard antimicrobial intervention.

Methods: A total of 62 eyes of 61 patients referred for both acute and chronic corneal ulcers were cultured by direct culture media plating or E-Swabs sent to a local microbiology laboratory. Following IRB approved informed consent patients were treated with FAR UV 222 nm UV light. Fifty-eight patients underwent 60 seconds of treatment for presumed bacterial or fungal keratitis and 3 patients underwent 15 minutes of treatment for clinically consistent *Acanthamoeba* corneal ulcers. One of these *Acanthamoeba* patients had bilateral infections and both eyes were treated. After treatment the corneal ulcers were again cultured and the specimens sent to the same reference laboratory.

Results: Twenty-one patients were culture positive before FAR UV intervention and were culture negative after therapy. Thirty patient eyes were culture negative before treatment and remained culture negative after FAR UV. Seven ulcers were culture positive both before and after therapy. Two patients were culture negative before treatment and had positive cultures after treatment.

Conclusions: FAR UV 222 nm treatment of corneal ulcers is efficacious in eliminating many bacterial and fungal culture proven corneal ulcers. Although the presenting ulcer may be sterilized by FAR UV treatment, recrudescent infection from residual organisms in the conjunctival fornices may ensure and topical medications should be continued until inflammation subsides.

Keywords: Corneal ulcers, Bacterial keratitis, *Acanthamoeba*, Fungal infections

Introduction

Microbial infections of the cornea are increasingly resistant to antibiotics, antifungals and antivirals [1–10]. We have investigated the use of FAR 222 nm UV light as adjunctive treatment in the treatment of acute and chronic corneal ulcers, many of which persist in the face of extant antimicrobial therapy. The Sterilray[T] provided by HEO3 was considered a good candidate for sterilizing corneal ulcers as it kills known common corneal pathogens, including *Staphylococcus*, *Streptococcus*, *Pseudomonas*, *Serratia*, *E. coli*, *Candida*, and *Fusarium* with under 20 seconds of application [11–18]. *Acanthamoeba* trophozoites and cysts can be killed in 7 minutes of application.

Materials and Methods

All study patients and protocols were obtained by HIPPA regulations. The corneal ulcer protocol was approved by the Western Institutional Review Board Study No : 1171772. In this study we recruited Florida patients that were resistant to current therapeutic interventions, had undergone unsuccessful therapy outside of our Institute, or were referred for acute corneal ulcers. All patients underwent a complete eye examination including visual acuity (VA), external exam, intraocular pressure (IOP) if no perforation was imminent, slit lamp exam, and fundus evaluation when visualization through the ulcer was possible.

Patients were precluded from this study in the following categories:

1. Corneal perforation requiring immediate corneal transplantation
2. Patients unable to undergo a complete eye exam.
3. Inability to understand the significance of corneal infection and potential loss of vision without proper intervention.
4. Life expectancy under one month.

All patients were shown the activated UV lamp (**Figure 1**), before treatment, and informed of the treatment parameters requiring a lid speculum, ocular stability for 60 seconds, the need for a second culture after the treatment and the requisite follow up and drop regimen after therapy. No adverse effects from the UV treatment have been observed and this information was also provided to the patients.

Results

Seventy-nine patients have been evaluated and treated with the protocol outlined. Twenty-one patients were culture positive before FAR UV intervention and were considered a success, being culture negative immediately after therapy. A broad spectrum of culture positive organisms were seen (**Table 1**).

Thirty-one patient eyes were culture negative before treatment and remained culture negative after FAR UV. Seven ulcers were culture positive both before and after therapy. Two patients were culture negative before treatment and had positive cultures after treatment.

Discussion

Corneal ulcers continue to occur, primarily from contact lens use [18,19], foreign bodies [20,21], and increasingly from nosocomial exposure [22]. The cultured ophthalmic organisms are increasingly resistant to current antibiotics or combinations thereof. Ultraviolet light has been utilized for sterilization for years for drinking water [23], air handling systems [24], operating rooms [25], and surgical instruments [26]. The shorter the UV wavelength the greater the killing power of UV light [27]. Therefore, the 222 Far UV light is a potential advance for superficial infections [28]. 222 Far UV provides excellent antimicrobial efficacy without the harmful skin effects of longer UV wavelengths [29]. The 222 wavelengths do not penetrate the stratum corneum of the skin and would be blocked by an intact epithelial layer of the cornea [30]. However, this epithelial layer is frequently absent in the presence of infectious corneal ulcers, allowing 222 UV penetration to superficial infections. Our unpublished

Figure 1. The handheld 222 nm FAR UV treatment unit.

Table 1. Summary of patient cultures.

Organism	Culture Positive Before FAR UV – Negative after UV	Culture Positive Before and after Far UV	Culture Negative Before FAR UV And Positive After
Staphylococcus epidermidis	6		
Staphylococcus aureus	2	3	
Streptococcus	2	1	
Pseudomonas	2		1
Serratia	2		
Propionibacterium acnes	1		
Bacillus	1		
Klebsiella	1		
Candida	2		
Aspergillus	1		
Fusarium	1	3	
Enterobacter			1
Total	21	7	2

SEM safety data demonstrated no endothelial toxicity in eye bank eyes from application of the 222 UV wavelength to the external cornea. We have, therefore, utilized this shorter wavelength UV for corneal ulcers with IRB approval. Rose Bengal photodynamic antimicrobial therapy has been utilized successfully for Pseudomonas keratitis isolates [31], Acanthamoeba Keratitis [32], Nocardia keratitis [33], and fungal keratitis [33] requiring 15–45 minutes of application and treatment time. We feel the 60 second killing power of the 222 wavelengths may be an auspicious advance for bacterial and fungal keratitis.

We noted that many of the ulcers had been treated for 1-90 days before referral, and this confounding variable may have accounted for the 31 negative culture results before any UV therapeutic intervention. The ulcers were not healing but had been adequately treated for infection before referral and the attendant ulcer tissue damage precluded epithelialization of the corneal surface. We are not able clinically to differentiate those corneal ulcers that remain infected at presentation and those which are already sterilized. We felt that delay of UV treatment for one to two weeks for initial culture results while routine ulcer treatment continued would not be safe or diagnostic.

Seven patients were culture positive before Far UV treatment and remained positive after UV treatment. Three of these ulcers were *Fusarium*. One additional patient with a *Fusarium* ulcer was culture negative after UV treatment. In addition, we have noted that some patients cannot easily tolerate the lid speculum and their eye movement during the two minutes of cultures, UV treatment and subsequent repeat cultures may allow reinoculation of the surface from untreated fornix organisms. Fornix organisms are not diminished or effaced by corneal treatment alone. In addition, in preclinical safety eye bank eye testing we found that Far UV light does not penetrate the cornea to the endothelium and this superficial level of treatment (250 microns) penetration may allow organisms to remain viable below the treated corneal surface. A corneal opacity may further block transmission of the FAR UV light to deeper corneal infections.

Two eyes had negative cultures before UV treatment but grew out organisms after the UV treatment: *Pseudomonas* (1), *Enterobacter cloacae* (1). This result may also be related to the culturing algorithm unavoidable eye movement.

The 222 Far UV light eliminated culture positivity in 21 of 28 infected eyes while 7 remained positive even with treatment. Many patients noted prompt relief of their ocular ulcer pain within hours of intervention. However, all patients should remain on standard ulcer therapy regiments until stromal inflammation subsides as fornix organisms will not be mitigated by corneal UV treatment alone. Adjacent skin flora may extend over the face with recontamination of the eye even as the ulcer heals. Therefore, prophylactic treatment for several weeks is appropriate even though ulcer treatment appears satisfactory. Longer UV wavelengths with deeper corneal penetration are anticipated.

Enhanced Disclosure

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High Energy Ozone LLC, 30 Centre Road, Suite 6, Somersworth, NH 03878.

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S. Edward Neister, John Neister, Steve Hudson are all owners of HEO3. No other author has any financial interest in the Far 222 UV device or any financial disclosures.

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