Journal of Microbiology, Immunology and Infection (2017) 50, 270–276

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jmii.com

ORIGINAL ARTICLE

Monitoring the decontamination efficacy of the novel Poseidon-S disinfectant system in dental unit water lines

Mari Fujita, Izumi Mashima, Futoshi Nakazawa*

Department of Oral Microbiology, School of Dentistry, Health Sciences University of Hokkaido, Hokkaido, Japan

Received 9 February 2015; received in revised form 10 April 2015; accepted 5 May 2015
Available online 14 May 2015

KEYWORDS
cytotoxicity;
dental unit water lines (DUWLs);
disinfection system;
electrolyzed water;
microbial contamination

Abstract *Background:* Contaminated dental unit waterlines (DUWLs) are a known source of specific health care-acquired infections because of the difficulty in keeping them clean during routine dental practice. Recently, an electrolysis apparatus that uses only the chlorine normally present in municipal water, the Poseidon-S system, was developed as a novel additive-free disinfectant system to control microbial contamination in DUWLs.
Methods: The microbiological quality of water samples collected from DUWLs was assessed before and after installation of the Poseidon-S system in terms of the total viable counts (TVCs) of microorganisms. The microbicidal effects of the electrolyzed water against oral organisms and its cytotoxicity against human oral-derived cell lines were also examined.
Results: Water samples from the DUWLs initially had average microbial TVCs of 10^3–10^6 colony-forming units (CFU)/mL. After installation of the Poseidon-S system, the number of microorganisms in the water samples decreased to less than 1×10^2 CFU/mL. The electrolyzed water also exhibited remarkable microbicidal effects on the microorganisms present in the DUWLs as well as microorganisms commonly isolated from human oral cavities, but showed low cytotoxicity towards human oral-derived cells.
Conclusion: This study demonstrated that routine use of the Poseidon-S system can effectively maintain low microbial levels in DUWLs.

* Corresponding author. Department of Oral Microbiology, School of Dentistry, Health Sciences University of Hokkaido, 1757 Kanazawa, Ishikari-Tobetsu, Hokkaido 061–0293, Japan.
E-mail address: nakazawa@hoku-iryo-u.ac.jp (F. Nakazawa).

http://dx.doi.org/10.1016/j.jmii.2015.05.006

Introduction

Studies conducted over the last 40 years have demonstrated that the water output from dental unit waterlines (DUWLs) is often contaminated with high densities of environmental microorganisms such as aerobic heterotrophic bacteria.[1–3] The American Dental Association (ADA) established a recommendation that, by the year 2000, water used for nonsurgical procedures should contain no more than 200 colony-forming units per milliliter (CFU/mL) of aerobic, mesophilic, or heterotrophic bacteria in unfiltered output from DUWLs (American Dental Association 1996).[4] Nevertheless, DUWLs typically used in dental practices are rarely disinfected, and bacterial contamination levels $>10^2$—10^6 CFU/mL have regularly been reported.[1,5,6] In particular, the formation of biofilms presents difficulties in maintaining clean DUWLs during routine dental practice.[5] Many contaminating microbial genera have been isolated and identified in water samples collected from dental units (DUs).[1–3]

Previous studies have focused on the effectiveness of numerous disinfectants used for the cleaning and maintenance of DUWLs.[7–9] In recent years, the use of herbal disinfectants such as *Aloe vera* solutions, as an alternative to chemical disinfectants has also been examined.[10,11] However, their efficacy is not well recognized. Due to its low toxicity, electrolyzed water has also attracted attention as an effective disinfectant in various fields, including agriculture, food industries,[12,13] medicine,[14] and dentistry.[15–17] Recently, an electrolysis apparatus known as the Poseidon-S (Self Medical Co., Kyoto, Japan) was developed as a novel disinfectant system. The Poseidon-S system controls microbial contamination in DUWLs without the need for sodium chloride solutions and provides high quality water to patients. In this system, a sensor detects the flow of water and supplies an electric current to the electrolyzer to oxidize the chloride ions (Cl^-) in water to chlorine (Cl_2). The chlorine immediately reacts with water to form hypochlorous acid (HClO) and hypochlorite ions (ClO^-), which, like free chlorine, have strong microbicidal effects.[18,19] Typically, electrolyzed neutral water is produced by mixing municipal water and a solution obtained by electrolyzing sodium chloride.[20] Such water is characterized by a pH of 5.5—7.5, an oxidation-reduction potential (ORP) of 600 mV—800 mV, and a chlorine concentration of ~20 ppm.[15] However, the advantage of the Poseidon-S system is that sodium chloride is not required to produce electrolyzed water, allowing for a direct connection to DUWLs and eliminating the cost of additives.

The purpose of the present study was to investigate the microbicidal effects of the electrolyzed water produced by the Poseidon-S system (hereafter, P-water) on microorganisms from DUWLs and assess any cytotoxic effects on cell lines derived from the human oral cavity. This study was performed to verify the safety and efficacy of the Poseidon-S system applied to DUs for reducing the microbial contamination of the water output from DUWLs.

Materials and methods

Measurement of residual chlorine

Residual chlorine levels in municipal water and P-water were measured using a Chlorine Meter (Hach Chlorine Pocket Colorimeter II 58700-00; Hach Company, Loveland, CO, USA). pH and ORP were determined using a pH meter (F-51; Horiba Co. Ltd., Kyoto, Japan), with a pH electrode (9680-10D; Horiba Co. Ltd.) or an ORP electrode (9300-10D; Horiba Co. Ltd.), respectively.

Collection of water samples from DUWLs before installation of the Poseidon-S system

Two DUs (DU-A and DU-B; Yoshida Dental Mfg. Co., Ltd., Tokyo, Japan) were selected from the available units at the Dental Hospital of the Health Sciences University of Hokkaido in Hokkaido, Japan. The DUs were linked to the municipal water system and had been used for daily dental work for 20 years. Although the DUs were regularly flushed, they were only cleaned for the first time during the present study. However, this is not surprising since typically DUWLs are rarely disinfected, and bacterial contamination levels greater than 10^2—10^6 CFU/mL have been regularly reported.[1,5,6] The total viable counts (TVCs) in the DUWLs in the current study were evaluated before installation of the Poseidon-S system, and it was found that the measured TVCs were within this range. These DUs were not used for dental work during the water sample collection period. Water samples (5 mL) were collected from the DUs at three sampling locations within the system: the air/water syringe (dentist's side), the high-speed dental handpiece, and the cup filler.

During the first 3-week period, both DUWLs were flushed four times a day (at 09:00, 12:00, 15:00, and 18:00) for 3 minutes each, every day from Monday to Friday. The water samples were collected after flushing at 09:00 on Tuesdays and Thursdays for the weekday water samples (WD-water; six samples per DU, 12 total). After weekends, during which no flushing occurred, weekend water samples were collected after flushing at 09:00 on Monday (WE-water; three samples per DU, six total). During the second 3-week period, the DUWLs of both DUs were flushed only on Monday at 09:00, 12:00, 15:00, and 18:00. Then, they were left undisturbed for 7 days, after which they were flushed on the following Monday at 09:00, and "after-vacation" water samples were collected (AV-water; three samples per DU, six in total).

Evaluation of the TVCs of microorganisms in water samples collected before installation of the Poseidon-S system

The microorganisms in 1 mL water samples collected from the DUs before installation of the Poseidon-S system were harvested, and serial 10-fold dilutions of the samples were prepared. Then, 0.1 mL aliquots of each sample were inoculated onto R2A agar plates.[21] The microorganisms were then cultured aerobically at 25°C for 5—7 days to