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Dental unit waterlines disinfection using hypochlorous acid-based disinfectant

Irfana Fathima Shajahan, D Kandaswamy, Padma Srikanth,[1] L Lakshmi Narayana,[2] and R Selvarajan[3]

Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Sri Ramachandra University, Porur, Chennai, Tamil Nadu, India

[1]Department of Microbiology, Sri Ramachandra Medical College and Research Institute, Sri Ramachandra University, Porur, Chennai, Tamil Nadu, India

[2]Thai Moogambigai Dental College and Hospital, Mogappair East, Chennai, Tamil Nadu, India

[3]Centre for Nanoscience and Technology, Anna University, Nuclear Physics Road, Kotturpuram, Chennai, Tamil Nadu, India

Address for correspondence: Dr. Irfana Fathima Shajahan, No. 2/3, Second Street, Ganapathy Colony, Opposite to Gopalapuram, Chennai - 600 086, Tamil Nadu, India. E-mail: sirfanafathima@gmail.com

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Abstract

Objective:

The purpose of the study was to investigate the efficacy of a new disinfectant to disinfect the dental unit waterlines.

Materials and Methods:

New dental unit waterlines were installed in 13 dental chairs, and biofilm was allowed to grow for 10 days. Disinfection treatment procedure was carried out in the 12 units, and one unit was left untreated. The dental unit waterlines were removed and analyzed using the scanning electron microscope (SEM) (TESCAN VEGA3 SBU).

Result:

On examination, SEM images showed that there was no slime layer or bacterial cells seen in any of the 12 cut sections obtained from the treated dental waterlines which mean that there was no evident of biofilm formation. Untreated dental unit waterlines showed a microbial colonization with continuous filamentous organic matrix. There was significant biofilm formation in the control tube relative to the samples.

Conclusion:

The tested disinfectant was found to be effective in the removal of biofilm from the dental unit waterlines.

Keywords: Biofilms, dental chair, disinfectant

INTRODUCTION

Contamination in the dental unit waterlines is known more than 30 years.[1] The sources of contamination were microcolonies containing proliferating bacteria, fungi, and protozoa called biofilm.[1,2] Dental unit waterlines are 3–4 m flexible, narrow tube made of plastic material; the surface of the tube enhances the biofilm formation.[3] During due course of usage for cooling the handpiece and flushing, the biofilm-coated untreated dental unit waterlines allows the microorganism to disperse through the water network and poses a risk to the dentist, dental team, and patients to pathogens through aerosolization of dental water from the dental equipment.[4] More than forty genera or species were identified from the dental unit waterline biofilms; the predominant pathogenic organisms were Gram-negative organisms which produce endotoxins and can cause fever, mild inflammation to septic shock.[5,6] To minimize the risk of infection in the dental environment, precautions such as rubber dam, high-volume suction, and antiretraction valve were used.[7] However, the long-term solution to overcome this issue lies in redesigning the dental unit to prevent biofilm formation, and the short-term solution disinfects the dental unit waterlines.[8]

Recent research has thrown light into a new disinfection solution based on hypochlorous acid, for use as a cleaning agent in dental unit waterlines. This study was undertaken to study the efficacy of a new disinfectant in dental practice.

MATERIALS AND METHODS

The study was undertaken in a dental college, Faculty of dental sciences, Sri Ramachandra University, Chennai. The study commenced with 13 dental chairs which were identified and labeled. New plastic tubes were installed in the dental chair and supplied with municipal water. During the observation period, the conservative and endodontic procedure was carried out. Eventually, biofilm was allowed to grow in the dental units for 10 days. Disinfection treatment procedure was carried out in the 12 units, and one unit was left untreated.

On the 10^{th} day, 200 ml of disinfectant solution (clean cert) (CleanCert, Unit, 16b Wyndham Place, Tisbury, Wiltshire SP3 6GS UK) was added to the booster of the 12 dental chairs. The disinfectant solution was made to run through the system until the solution appeared at the end of the air/water syringe and handpiece lines. The disinfectant solution was allowed to remain in the dental unit waterlines for overnight. At the beginning of the next workday, the remaining disinfectant solution was discarded from the booster bottle. The bottle was filled with water; each of the dental unit waterlines was flushed until the residual solution was washed out. Water from aqua guard was made to run through the tubing.

The dental unit waterlines from the 13 dental chairs were removed and 1 inch of the dental unit waterline tube was cut at random site and the removed piece of tube was cut along the lengthwise using a sterile blade. The cut section samples were analyzed using the scanning electron microscope (SEM) (TESCAN VEGA3 SBU).

Tubing samples are fixed in 2% glutaraldehyde and washed in phosphate buffer solution for 10–15 min to remove the fixative. Dehydration was carried for 10 min through 30%, 50%, 70%, 90%, and 100% series of alcohol, and the final treatment was done with hexamethyldisilazane (for 10 min) and air dried overnight. The specimens were mounted on SEM aluminum mounts and coated with gold-palladium.

RESULTS

To investigate the efficacy of the disinfection protocol or disinfectant, the presence or absence of the biofilm in the treated and untreated dental unit waterlines was evaluated using SEM. The treated 12 dental unit waterlines cut section obtained from the treated dental unit waterlines were named as samples (a-l), and the cut section obtained from the untreated dental unit waterline was named as control tube. The surface feature of the inner lumen of the cut section samples collected from both treated and untreated dental unit waterlines was examined. SEM images demonstrate the 12 cut section samples collected from the treated dental unit waterlines [Figure 1 (a-l)]. On examination, there was no slime layer or bacterial cells seen in any of the 12 cut sections obtained from the treated dental unit waterline which means that there is no evident of biofilm formation. The surface characteristics of the cut section collected from the untreated dental unit water lines that had been used for an extended period of 10 days showed a microbial colonization with continuous filamentous organic matrix which was indicated using arrow marks as shown in Figure 2. There was significant biofilm formation in the control tube relative to the samples (a-l). The cut section of the dental unit waterlines examined with SEM revealed the difference between the treated and untreated dental unit waterlines [Figure 2].

DISCUSSION

Hypochlorous acid-based disinfectant, the newly discovered disinfectant manufactured in the United Kingdom, is an aqueous solution prepared by the electrolysis of sodium chloride through an electrolytic cell.

Disinfection procedure was carried out overnight in all the dental unit waterlines, except control tube. After allowing the disinfectant to act on the biofilm in the dental unit waterlines for overnight, all the tested samples showed no biofilm.

Biofilm formation is the complex process involving initial attachment of microorganisms to the surface, followed by irreversible attachment which is facilitated by the production of extracellular polymeric substances, often referred to as glycocalyx or slime. The biofilm contamination is a dynamic process involving several factors such as long periods of stagnation, high surface-to-volume ratio, nutrient content in the water, mineral content and hardness of water, facilitating inorganic coating of the lumen, fluid dynamics, such as laminar flow, low flow rate, and microbial quality of the water entering the system.[9]

Flushing the handpiece is the common procedure carried out to reduce the microbial count in the dental unit waterlines.[10] Although it reduces the microbial content in the dental water, biofilm still exists adhering to the inner wall of the dental unit waterlines, thereby contaminating the incoming water.[11,12] Various disinfectant solutions are used to remove biofilm from the dental unit waterlines such as chlorhexidine gluconate,[13] hydrogen peroxide,[14] Listerine mouthwash,[15] povidone–iodine,[16] and electrochemically activated water.[17]

The effectiveness of tested disinfectant in this study could be attributed to the individual action of each of its constituents. The constituents were sodium chloride, hypochlorous acid, and sodium hypochlorite. The active ingredient in the disinfectant agent is stabilized hypochlorous acid which is a strong oxidizing agent which invades DNA and RNA of the invading pathogens, killing the pathogens by disrupting the oxidative phosphorylation, metabolic pathway involved in ATP generation.[18,19,20] Sodium chloride acts as a bleaching agent.

Physical and chemical properties of the disinfectant agent are clear, liquid, water soluble with slight chlorine smell, and it does not produce any decomposition product. Extreme temperatures can affect their efficacy; therefore, prolonged exposure to direct UV light, heat (above 22°), and CO_2 will render the product in effective. Hence, it is essential to store them at a suitable temperature.

The units used in this study had new dental unit waterlines installed as to have standardized duration for biofilm formation. In this study, SEM images show the absence of biofilm in the treated dental unit waterlines which show the efficacy of a disinfectant. The presence of dense biofilm in the control tube within 10 days elaborates the rapid formation of biofilms in the newly installed dental unit waterlines within a short period of duration which emphasize the need for disinfection in the dental practice to reduce the risk of infection caused by the pathogenic organism in the biofilm.

Few case reports were published about the infection acquired on exposure to aerosol produced during dental treatment.[21,22] The inhalation of infectious aerosols or direct inoculation of traumatized tissue results in infection or disease in the host. Literature reveals that in 1987, p.aeruginosa was isolated from the matrix band traumatized site after amalgam restoration in two patients and the same organism was identified from the dental unit waterlines. This is due to the direct inoculation of traumatized tissue with contaminated dental water.[21] *Legionella* species such as *Legionella pneumophila* are capable of causing Legionnaire's disease. A case of death was reported in California due to Legionnaire's disease;[22] however, there is no outbreak of such disease in India.

The disinfecting solution used in this study seems to be promising as there was no biofilm in the tested samples [Figure 1]. Hence, efficacy of the disinfectant was proved beyond doubt, but it should also be economical which relays on the substantively of the disinfection. Therefore, substantivity of the disinfectant will be analyzed in future. Thus, on analysis of the disinfectant substantivity, a firm conclusion can be made.

CONCLUSION

Based on the result obtained from SEM, we conclude that usage of disinfectant was found to be effective in the removal of biofilm from the dental unit waterlines. Eventually, it is also essential to have a good source of water and the use of antiretraction valves along with a disinfectant to maintain a sterile environment in the dental unit waterlines.

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Conflicts of interest

There are no conflicts of interest.

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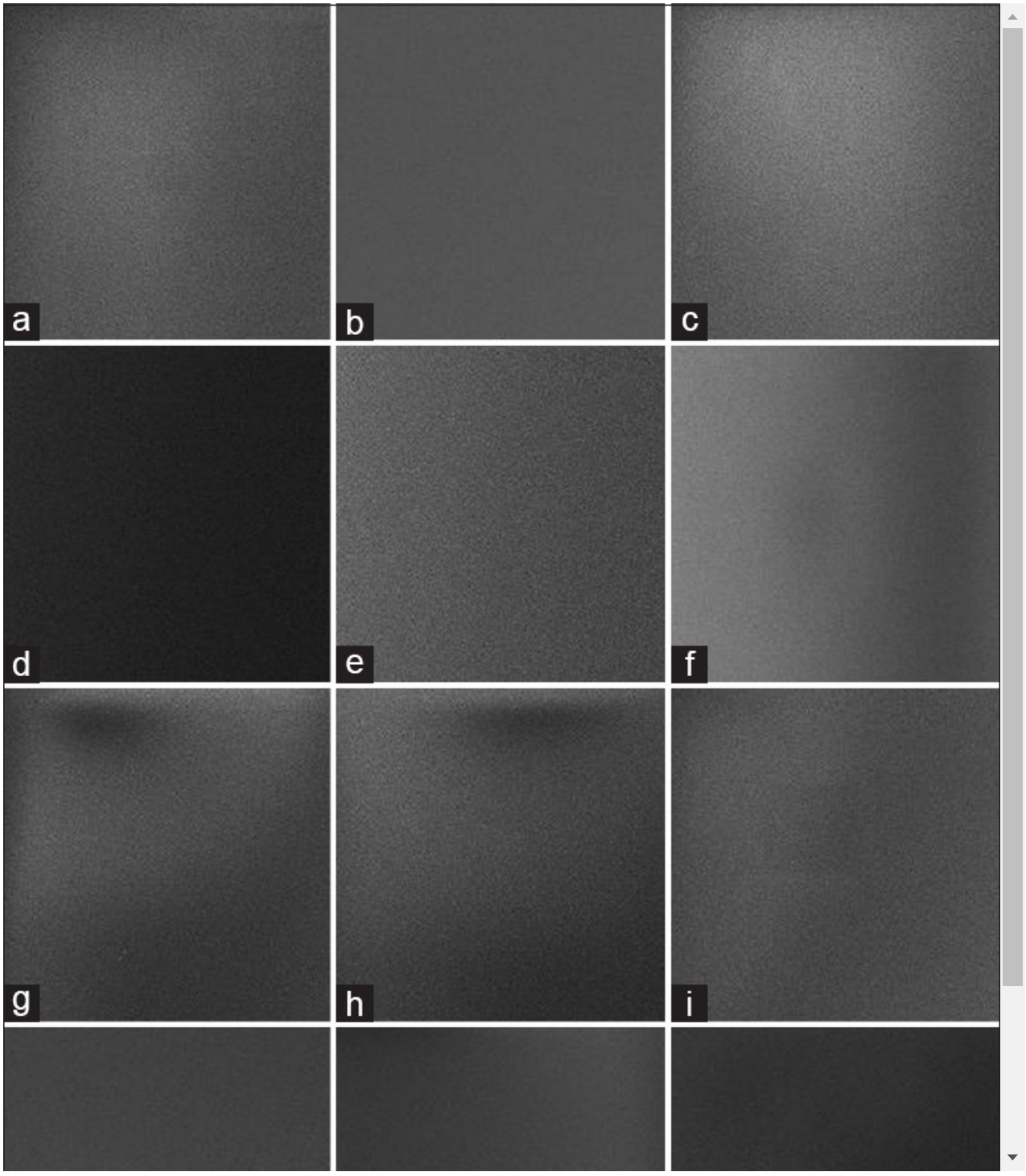
Figures and Tables

Figure 1



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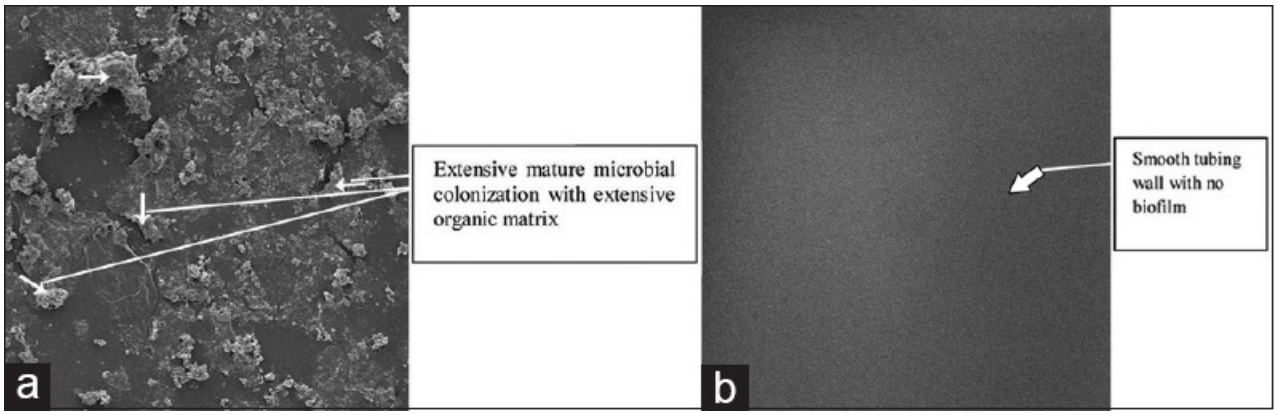
(a-l) Represents scanning electron microscope images of the inner luminal wall of the cut section tube collected from the 12 dental unit waterlines after overnight disinfection the 12 dental unit waterlines. There was no evidence of extensive microbial colonization or biofilm

Figure 2



Scanning electron microscope images show the efficacy of the disinfectant or disinfection procedure. (a) The inner lumen wall of the cut section from the untreated dental waterlines (control tube) and the arrow indicates extensive mature microbial colonization with extensive organic matrix material. (b) The inner lumen of the cut section of treated dental unit waterline (sample a) and the arrow indicates the smooth tubing wall with no biofilms