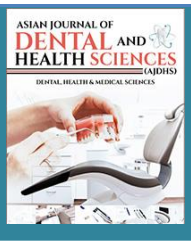

Available online at ajdhs.com

Asian Journal of Dental and Health Sciences

Open Access to Dental and Medical Research

Open Access Research Article

Sterilization of Toothbrushes using Ultraviolet-C Light against Streptococcus Mutans Bacteria

Afifah Noor Rahmah *, Diyah Fatmasari, Endah Aryati Eko Ningtyas

Ministry of Health Semarang Health Polytechnic, Indonesia

Article Info:

Article History:

Received 22 March 2024
Reviewed 05 May 2024
Accepted 28 May 2024
Published 15 June 2024

Cite this article as:

Noor Rahmah A, Fatmasari D, Aryati Eko Ningtyas E, Sterilization of Toothbrushes using Ultraviolet-C Light against Streptococcus Mutans Bacteria, Asian Journal of Dental and Health Sciences. 2024; 4(2):17-20

DOI: http://dx.doi.org/10.22270/ajdhs.v4i2.78

*Address for Correspondence:

Afifah Noor Rahmah, Ministry of Health Semarang Health Polytechnic, Indonesia

Abstract

Background: Streptococcus mutans bacteria are the dominant cariogenic bacteria that can be found in dental caries and are able to survive and reproduce at low pH. Toothbrush storage is related to environmental humidity and existing bacteria. Bacterial growth is 70% higher in wet and closed environments, bacteria from the oral cavity can be carried on the toothbrush.

Aim: This research is to produce a model for storing toothbrushes with ultraviolet-C against the growth of Streptococcus mutans bacteria.

Materials and Method: Research with Research and Development (R&D) method with a quantitative approach with 5 stages, namely information gathering, model design, expert validation and revision, model trials, and model results. The design used is Randomize Pretest-Posttest with Control Group Design using 5, 10, and 15 minutes of ultraviolet-C treatment groups and a control group of toothbrushes stored standing without treatment using ultraviolet-C.

Results: The results of model expert validation using the aiken-v test showed 0.810, meaning that all question items were declared valid. The ICC results show 0.000, meaning that the toothbrush storage model with ultraviolet-C is feasible as an effort to reduce the number of Streptococcus mutans bacterial colonies. Two-Way Anova results show 0.000, meaning that there is a significant time difference between the control group and the 5, 10, and 15 minute sterilization groups. Post-Hoc LSD results showed 0.000, meaning there was a significant difference in the 5, 10, 15 minute treatment group, and the control group. The Pearson Sig. (2-tailed) correlation result is 0.000, meaning that there is a significant relationship between the length of time and the number of Streptococcus mutans bacteria. The results of the bacterial repetition test showed that 15 minutes was the most effective time to kill Streptococcus mutans bacteria. The results showed that the average number of bacteria decreased by 74%, 86%, and 100% after using ultraviolet-C for 5, 10, and 15 minutes. Obtained showed that 15 minutes was the most effective for killing Streptococcus mutans bacteria.

Conclusion: The results showed that the average number of bacteria decreased by 74%, 86%, and 100% after using ultraviolet-C for 5, 10, and 15 minutes. Developing a model for storing toothpaste with ultraviolet- C for 15 minutes is effective in reducing Streptococcus mutans bacteria.

Keywords: Streptococcus mutans, toothbrush, Ultraviolet-C

INTRODUCTION

Dental and oral health is part of general health which can affect general health directly or indirectly. Oneof the correct ways to maintain oral hygiene is by brushing your teeth using a toothbrush which can remove plaque[1]. Caries is one of the dental and oral health problems that is often experienced by people which starts from the growth of plaque on the teeth in the oral cavity[2].

There is a microbiome in the oral cavity which has an important role in maintaining the oral environment to remain normal and stable[3]. In the oral cavity there is saliva which contains various cariogenic bacteria such as Streptococcus mutans bacteria which are aciduric and acidogenic, namely bacteria that can live inan acidic environment and can produce acid[4]. Caries is a dental disease in which the hard tooth tissue is damaged due to the metabolic activity of bacteria in plaque which causes demineralization[5]. Caries disease in Indonesia is mostly experienced by those aged 25-64 years, amounting to 87.0% – 96.8% according to 2018 Basic Health Research (RISKESDAS) data [6].

The human oral cavity functions as a connecting channel between the external environment, the digestive tract, and the respiratory tract. Microorganisms in the oral cavity need appropriate nutrition, temperature and humidity. There is a microbiome microbiota in the oral cavity which has an important role in maintaining a normal and stable oral environment[3]. In the oral cavity there is saliva which contains various cariogenic bacteria such as Streptococcus mutans bacteria which are aciduric and acidogenic, namely bacteria that can live in an acidic environment and can produce acid[4].

The acidic environment produced by bacteria can trigger a demineralization process in the enamel so that plaque growth will occur to cause caries lesions[5]. Caries is a dental disease in which the hard tissue of the tooth is damaged due to the metabolic activity of bacteria in the plaque which causes demineralization. Plaque is one of the factors causing dental caries which consists of a population of bacteria. One of the bacteria that can be found in dental caries is Streptococcus mutans.

One of the bacteria that can be found in dental caries is

Streptococcus mutans. This bacterium is the dominant cariogenic bacterium that can be found in dental caries and can produce acid, and is able to survive and multiply at low pH (aciduric)[5]. Streptocuccus mutans bacteria are non-motile, facultative anaerobes, and Gram-positive coccus arranged like a chain and have various proteins and enzymes. The process of attachment and virulence of bacteria on the tooth surface is the role of these proteins and enzymes. One way to prevent caries is by cleaning plaque, namely by brushing your teeth[7].

The most common mechanical method used by people to control plaque is by brushing their teeth. The toothbrush used can contain a lot of bacteria that can contaminate the oral cavity. Contaminated toothbrushes cancause oral and systemic diseases, digestive disorders, cardiovascular disease, respiratory disorders and kidney disease[7]. Toothbrush storage is related to environmental humidity conditions and the bacteria present. Toothbrushes that are stored open have fewer bacteria than closed toothbrushes.

Using an ultraviolet-C lamp on pathogenic bacteria for 5, 10 and 15 minutes can kill and inactivate the bacteria. One of the efficient sterilization techniques is using ultraviolet-C germicidal irradiation. The process of killing bacteria based on type C ultraviolet (UV) is more effective in deactivating bacteria. Ultraviolet-C radiation is more effective at killing pathogens on surfaces and can effectively sterilize unexposed areas. Ultraviolet-C lightcan be used to disinfect items that can be reused or safely disposed of in the environment[8].

METHOD

This research uses the Research and Development (R&D) method with a quantitative approach, using a true experiment design using a Randomized Pretest-Posttest with control group design. This research procedure includes 5 main steps, namely as follows; 1) information collection, 2) product/model design, 3) expert validation and revision, 4) product/model testing, and 5) product/model results.

This method was used to produce and test the effectiveness of a model product for storing toothbrushes with ultraviolet-C using a quantitative approach. The research results are divided into five stages, namely: information collection, design, expert validation and revision, model testing, model results.

This research was carried out at the Microbiology Laboratory to test a toothbrush storage model with ultraviolet-C against Streptococcus mutans bacteria in 3 treatment groups with a duration of using the model of 5 minutes, 10 minutes and 15 minutes. There was a control group with wet toothbrushes and dry toothbrushes without treatment using a toothbrush storage model with ultraviolet-C against Streptococcus mutans bacteria in order to determine the differences between groups and test the effectiveness of the toothbrush storage model withultraviolet-C against Streptococcus mutans bacteria.

Information collection is carried out by interviewing related knowledge about how to store toothbrushes with the aim of knowing how to store toothbrushes in a toothbrush storage area and as information on the importance of making a toothbrush storage model with ultraviolet-C against the growth of Streptococcus mutans bacteria.

The tool model is designed from the size of the tool specifications, model tools and materials, tool design is some description of the design of the tool / prototype of the toothbrush storage model with ultraviolet-C against the growth of Streptococcus mutans bacteria which includes the front model, the model when opened, and sensors and ultraviolet-C lamps. As well as the design of the electronic system and how the tool works.

Expert validation is carried out to determine whether the model to be created is valid and reliable. The results of the expert validity test were tested on aiken v to determine the validity of the question items and the Interclass Correlation Coeficient (ICC) test was conducted to determine the reliability of the question items. the results of the expert validity test using the aiken v test, obtained a V result of 0.810 which indicates that the value is included in the high criteria. It can be concluded that all question items are valid.

The feasibility of a toothbrush storage model with ultraviolet-C against the growth of Streptococcus mutans bacteria using the Interclass Correlation Coeficient (ICC) test resulted in a value of 0.722 with a good category, the p-value of 0.000 indicates that the toothbrush storage model with ultraviolet-C is feasible in reducing the number of colonies of Streptococcus mutans bacteria.

The results of expert validation that have been carried out to determine the feasibility of the product/model can be seen that the development model of toothbrush storage with ultraviolet-C against the growth of Streptococcus mutans bacteria is relevant and has received a model feasibility assessment from 6 validators, after the model/product assessment is carried out, it is necessary to test the product/model which aims to analyze the effectiveness of the product/model.

The product results in the form of a toothbrush sterilizer with ultraviolet-C are expected to provide benefits as a tool to sterilize toothbrushes and reduce the number of Streptococcus mutans bacteria found on toothbrushes that can be used easily by the community.

RESULTS AND DISCUSSION

The identification test of Streptococcus mutans bacteria using Nutrient Broth (NB) liquid media which aims as a bacterial culture medium and to fertilize bacteria. The results showed that there were Streptococcus mutans bacteria on the toothbrush before use in a dry state without rinsing, the toothbrush before use was wet because it was rinsed, and the toothbrush after use was wet because it was rinsed. Repetition tests were carried out on Streptococcuc mutans bacteria for 5 minutes, 10 minutes, 15 minutes and control groups of wet toothbrushes and dry toothbrushes. The suspension concentration used was 10^5. This repetition test was carried out using the same ultraviolet-C lamp.

The results of interviews conducted with 6 experts (2 microbiologists, 2 electromedical experts, a dentist, and a dental and oral therapist), namely, the way toothbrushes are stored by the general public influences the number of bacteria found on toothbrushes. The number of bacteria found on the toothbrush can be influenced by the place where the toothbrush is stored, namely inside/outside the bathroom, the position in which the toothbrush is stored, the use of toothbrush headgear, the length of time the toothbrush is used, the storage of toothbrushes at the same time, and the location. Storing conventional toothbrushes separately and standing. The results further show that there are recommendations to develop a model for storing toothbrushes with ultraviolet-C in order to reduce the number of bacteria/influence the growth of bacteria found on toothbrushes. The results of the validity and reliability tests were declared valid and reliable that the toothbrush storage model could reduce the number of Streptococcus mutans bacteria.

Table 1

Test	Dry Control	Wet Control	Sterilization Time		
			5 minutes	10 minutes	15 minutes
1	502	500	155	90	0
2	491	490	134	88	0
3	523	520	160	76	0
4	500	500	158	81	0
Average	504	503	152	84	0

Table 1 is a table of results from 4 experimental tests in the treatment group and control group. The results of the research that was carried out on toothbrushes which were carried out 4 repetitions of tests were obtained from the Leokitto formula using a toothbrush storage model with ultraviolet-C against Streptococcus mutans bacteria at a sterilization time of 5 minutes, namely that there was an average number of 152 colonies of Streptococcus mutans bacteria. , at a sterilization time of 10 minutes, there was an average number of 84 colonies of Streptococcus mutans bacteria, at a sterilization time of 15 minutes, there was an average number of 0 colonies of Streptococcus mutans bacteria or there were no Streptococcus mutans bacteria after treatment. The average result in the control group of wet toothbrushes that were not sterilized using an ultraviolet-C lamp was 503 colonies of Streptococcus mutans bacteria, in the control group of dry toothbrushes that were not sterilized using an ultraviolet-C lamp was 504 colonies of Streptococcus mutans batteries. .

The results of developing a toothbrush storage model with ultraviolet-C against Streptococcus mutans bacteria using two-way anova testing showed that there was a significant effect of sterilization time on the number of Streptococcus mutans bacteria between the 5 minute, 10 minute and 15 minute groups. The results of the LSD post-hoc test were that there was a significant difference between the sterilization time of 5 minutes, 10 minutes, 15 minutes, and the control group on the number of Streptococcus mutans bacterial colonies. The results of the Pearson correlation test are that there is a relationship between the length of time using the toothbrush storage model with ultraviolet-C and the number of colonies of Streptococcus mutans bacteria.

Streptococcus mutans bacteria are the dominant cariogenic bacteria that can be found in dental caries and can produce acid, and are able to survive and reproduce at low pH (aciduric). Streptococcus mutans bacteria have non-motile properties and are in the form of Gram-positive coccus which are arranged like chains and have various proteins and enzymes. The process of attachment and virulence of bacteria on the tooth surface is the role of these proteins and enzymes. This bacteria has facultative anaerobic properties, namely bacteria that can grow in the presence or absence of oxygen in their growth and metabolism, this is in line with Sulatri et al[9], hat no pathogenic bacteria grew after being treated using ultraviolet-C light, whereas in media that was not exposed to ultraviolet-C light, the growth of pathogenic bacterial colonies was full and could not be counted[10].

The most effective time to reduce the number of Streptococcus mutans bacteria on a toothbrush using an ultraviolet-C lamp is 15 minutes. Ultraviolet-C lamps are effective in killing bacteria because within a period of 5 minutes, the number of bacteria exposed to ultraviolet-C lamps has decreased by more than half the number of bacteria before exposure to ultraviolet-C rays. Streptococcus mutans bacteria on toothbrushes can be reduced due to exposure to ultraviolet-C light. Ultraviolet-C lamps can be effective in inactivating bacteria because ultraviolet- C radiation is more effective in killing pathogens and sterilizing the area[8].

Figure 1

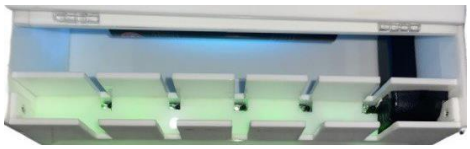

Figure 2

Figure 1 is a model for the development of toothbrush storage with ultraviolet-C against the growth of Streptpcoccus mutans bacteria that has been developed, namely the presence of a separately designed toothbrush storage area and a hanging toothbrush position. So bacteria do not easily grow because toothbrushes do not touch each other. Figure 2 shows the addition of ultraviolet-C light to the toothbrush storage development model which is provided to reduce the development of the number of Streptococcus mutans bacterial colonies. Type C ultraviolet lamps are more effective in inactivating bacteria. Ultraviolet-C radiation is more effective in sterilizing areas and killing pathogens on surfaces.

The role of ultraviolet-C lamps can influence the growth of bacteria, because ultraviolet-C rays can open membrane proteins and release tryptophan which can then cause an initial increase in the signal in the light emitted. With tryptophan taken from the cell membrane, there is space left to form a gaping hole for ultraviolet-C light to enter and damage DNA[11], so the bacteria will die[12]. A damp toothbrush storage area can cause bacteria to multiply more quickly. Keeping your toothbrush and toothbrush storage area clean is very important for dental and oral health, because if it is not cleaned, bacteria will grow on the toothbrush and storage area.

The model for storing toothbrushes with ultraviolet-C can

carry out the sterilization process and can reduce and kill and stop the growth of Streptococcus mutans bacteria because it is known that ultraviolet-C rays can enter and damage the DNA of bacteria, resulting in bacterial death[13].

CONCLUSION

The average number of Streptococcus mutans bacterial colonies on a wet/rinsed toothbrush before being treated using ultraviolet-C for 5 minutes was 590 bacterial colonies, and there were 152 bacterial colonies after being treated using ultraviolet-C. The average number of Streptococcus mutans bacterial colonies on a wet/rinsed toothbrush before being treated using ultraviolet-C for 10 minutes is 590 bacterial colonies, and there are 84 bacterial colonies after being treated using ultraviolet-C. The average number of Streptococcus mutans bacterial colonies on a wet/rinsed toothbrush before being treated using ultraviolet-C for 15 minutes is 590 bacterial colonies, and there are 0 bacterial colonies after being treated using ultraviolet-C. The average number of Streptococcus mutans bacterial colonies on a wet/rinsed toothbrush before being treated without using ultraviolet-C is 590 bacterial colonies, and there are 504 bacterial colonies after not being treated using ultraviolet-C. The average number of Streptococcus mutans bacterial colonies on a dry/unrinsed toothbrush before use and not treated with ultraviolet-C is 504 bacterial colonies, and there are 504 bacterial colonies after being given no treatment using ultraviolet-C.

The development of a model for storing toothbrushes with ultraviolet-C on the growth of Streptococcus mutans bacteria. In its implementation, it was effective in reducing the number of Streptococcus mutans bacteria,as evidenced by the decrease in the average number in each group of sterilization treatments using ultraviolet-C lamps for 5 minutes, 10 minutes, 15 minutes, and there was still growth of Streptococcus mutans bacteria in the control group on wet toothbrushes and dry toothbrushes.

The most effective time in reducing the number of Streptococcus mutans bacteria on a toothbrush using an ultraviolet-C lamp is at 15 minutes. Ultraviolet-C lamps are effective in killing bacteria because within a period of 5 minutes, the number of bacteria exposed to ultraviolet-C lamps has decreased by more than half the number of bacteria before being exposed to ultraviolet-C light. Streptococcus mutans bacteria on toothbrushes can be reduced due to exposure to ultraviolet-C light. Ultraviolet-C lamps can be effective in inactivating bacteria because ultraviolet-C radiation is more effective in killing pathogens and sterilizing areas.[8] There is a very strong relationship between time and the number of Streptococcus mutans bacteria, namely, the longer the irradiation time using ultraviolet-C lamps, the less even the absence of Streptococcus mutans bacterial growth.

The role of ultraviolet-C lamps can affect the growth of bacteria, because ultraviolet-C light can open membrane proteins and release tryptophan which can then cause an initial increase in the signal in the emitted light. The presence of tryptophan taken from the cell membrane, there is space left to form a gaping hole for ultraviolet-C rays that can enter and damage DNA[11], so the bacteria will die[12].

REFERENCES

1. Ghoni Tjiptoningsih U, Permatasari Fn. Pengaruh Penyimpanan Sikat Gigi Terhadap Kontaminasi Bakteri Pada Bulu Sikat Gigi. Mderj [Internet]. 2021;1(3):111-26. Available From: Https://Journal.Moestopo.Ac.Id/Index.Php/Mderj

2. Praptiningsih Rs, Amien Rw, Pratiwi R. Chewing Xylitol Candy And Probiotic Candy On The Growth Of Dental Plaque And Number Of Colony Of Sterptococcus Mutant Bacteria. Odonto Dent J. 2022;9(1):147. https://doi.org/10.30659/odj.9.0.147-154

3. Asghar F, Bano A, Waheed F, Ahmed Anjum A, Ejaz H, Javed N. Association Of Exogenous Factors With Molecular Epidemiology Of Staphylococcus Aureus In Human Oral Cavity. Saudi J Biol Sci [Internet]. 2023;30(4):103613. https://doi.org/10.1016/j.sjbs.2023.103613 PMid:36936700 PMCid:PMC10018566

4. Wulandari, Widodo, Hatta I. Hubungan Antara Jumlah Koloni Bakteri Streptococcus Mutans Saliva Dengan Indeks Karies (Dmf-T). J Kedokt Gigi. 2022;6(3):1-1.

5. Satrio R, Supriyati, Ashar F, Zahra S, Sari D, Ichsyani M. Isolasi Dan Karakterisasi Bakteri Kariogenik Padapasien Yang Terdiagnosis Pulpitis: Penelitian Observasional. J Kedokt Gigi Univ Padjajaran. 2023;35(April):61. https://doi.org/10.24198/jkg.v35i1.41439

6. Indonesia Kkr. Hasil Utama Riskesdas 2018. Kementerian Kesehatan Republik Indonesia. 2018.

7. Endriani R, Siregar Fm, Rafni E, Azhari Rk, Jefrizal J. <P>Identifikasi Gen Kariogenik Glukosiltransferase Streptococcus Mutans Pada Pasien Karies Gigi</P><P>Identification Of Streptococcus Mutans Cariogenic Gene Glucosyltransferase (Gtf) In Dental Caries Patients</P>. J Kedokt Gigi Univ Padjadjaran. 2021;33(1):14. https://doi.org/10.24198/jkg.v33i1.30397

8. Mahanta N, Saxena V, Pandey Lm, Batra P, Dixit Us. Performance Study Of A Sterilization Box Using A Combination Of Heat And Ultraviolet Light Irradiation For The Prevention Of Covid-19. Environ Res [Internet]. 2021;198(May):111309. https://doi.org/10.1016/j.envres.2021.111309 PMid:33984307 PMCid:PMC8107062

9. Sulatri Nl, Yogeswara Iba, Nursini Nw. Efektifitas Sinar Ultraviolet Terhadap Cemaran Bakteri Patogen Pada Makanan Cair Sonde Untuk Pasien Immune-Compremissed. J Gizi Indones (The Indones J Nutr. 2017;5(2):112-8. https://doi.org/10.14710/jgi.5.2.112-118

10. Assari As, Mohammed Mahrous M, Ahmad Ya, Alotaibi F, Alshammari M, Alturki F, Et Al. Efficacy Of Different Sterilization Techniques For Toothbrush Decontamination: An Ex Vivo Study. Cureus. 2022;14(1):1-13. https://doi.org/10.7759/cureus.21117

11. Ariyadi T, Dewi Ss. Pengaruh Sinar Ultra Violet Terhadap Pertumbuhan Bakteri. Vol. 2, Jurnal Kesehatan. 2009. P. 20-5.

12. Minnuthfatin Sa, Setyawardhana Rhd, Dwi Kurniawan Fk. Perbandingan Efektivitas Penggunaan Sikat Gigi Konvensional Dan Sikat Gigi Elektrik Terhadap Penurunan Indeks Plak (Literature Review). Dentin. 2022;6(2):87-90. https://doi.org/10.20527/dentin.v6i2.6392

13. Imasari T, Hidayatul F, Ayu Nabila Rizki Insani. Deteksi Bakteri Streptococcus Mutans Pada Sikat Gigi Dengan Perilaku Pemakaian Sikat Gigi Di Kost Putri X Kota Kediri. J Insa Cendekia. 2023;10(1):52-7.