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Efficacy of chlorine dioxide mouthwash against halitosis

M D Bestari, H Sunarto and Y Kemal*

Department of Periodontics, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia

*E-mail: yulianti.kemal@ui.ac.id

Abstract. To ascertain the effectiveness of using chlorine dioxide mouthwash in addressing halitosis. Forty people were divided equally into the test group (required to gargle with mouthwash containing chlorine dioxide) and the control group (required to gargle with aquadest). The volatile sulfur compound (VSC) and organoleptic scores were measured before gargling and 30 min, 2 h, 4 h, and 6 h after. The Wilcoxon test analysis showed a significant difference ($p<0.05$) in the mean value of VSC scores between the test group and the control group in four testing periods after gargling. Chlorine dioxide mouthwash is effective in addressing halitosis.

1. Introduction

Oral health is essential and has an important role in everyday life. In Indonesia, oral health remains one of the main problems suffered by the community. The Indonesian Household Health Survey in 2001 showed that oral health problems are the complaints of 60% of the Indonesian population. Dental and oral diseases, which are usually found among the people of Indonesia, include dental caries, periodontitis, gingivitis, stomatitis apthosa, and halitosis [1]. Halitosis or bad breath is defined as an unpleasant breath arising from physiological and pathological factors derived from oral or systemic sources and is one of the most frequent oral health problems. Several studies conducted in industrialized countries showed a prevalence of halitosis of as high as 50% with various severities [2]. Besides health problems, halitosis can also greatly affect the social life of patients.

About 80%–90% of halitosis comes from the oral cavity, and the accumulation of bacteria on the posterior part of the tongue is one of its main causes [3]. Halitosis can be caused by various factors, such as foods and drinks, poor oral hygiene, periodontal diseases, tongue coating, xerostomia (dry mouth), and systemic diseases [2]. Moreover, halitosis can be caused by upper and lower respiratory tract disorders, digestive disorders, and use of certain drugs [4]. Volatile sulfur compound (VSC) is the major cause of halitosis. The VSC components, are hydrogen sulfide gas (H_2S), methyl mercaptan (CH_3SH), and dimethyl sulfide ($(CH3)_2S$). VSC is formed through the reactions of non-volatile materials in the mouth, especially protein, with anaerobic bacteria in the oral cavity [2].

Prevention efforts and treatment of halitosis are brushing the teeth and the tongue, using mouthwash, and improving one's diet. Treatments such as brushing the teeth and tongue or using an antiseptic mouthwash have been proved to reduce hydrogen sulfide and methyl mercaptan, which are the components of VSC [5].

The use of mouthwash is a simple effort to overcome halitosis. Particularly in Indonesia, the market offers a wide variety of brands with different active ingredients of mouthwashes. Chlorhexidine is the most commonly used antibacterial agent. However, although chlorhexidine is one

of the most effective oral antiseptic agents, research shows that the long-term use of chlorhexidine has some side effects, such as staining on the teeth and tongue and reduced sensitivity of taste buds [6,7].

Developments in dentistry have produced several discoveries of new products that can be used as supporting periodontal treatment, one of which is chlorine dioxide (ClO_2). ClO_2 is a strong oxidizing agent that can kill bacteria through a protein synthesis mechanism [8]. It contains oxygen, which can be used as an antiseptic on wounds and accelerates healing, and is effective for halitosis, gingivitis, periodontitis, and bleeding gums [10-12]. ClO_2 and chlorite anion (ClO_2-) together can oxidize VSC to become a non-malodor product and destroy amino acids, such as cysteine and methionine, which are VSC precursors, in the process of oxidation [12]. Mouthwashes containing ClO_2 have been widely used in developed countries, such as Japan and the United States, and ClO_2 mouthwash has been reported to be effective in reducing bad breath in the morning (morning breath malodor) up to 4 h after application in healthy subjects [13]. In Indonesia, mouthwashes containing ClO_2 are not too popular among the public. Moreover, studies on the efficacy of the use of mouthwash containing ClO_2 against halitosis in Indonesia have not yet been conducted. Therefore, this research is conducted to analyze the efficacy of using mouthwash containing ClO_2 as the active ingredient to address halitosis. The results are expected to improve the knowledge of dentists in dealing with halitosis and to help people to choose the right mouthwash to overcome halitosis**.**

2. Materials and Methods

This study used a blind randomized clinical trial by taking samples randomly before and after the study. Data retrieval was conducted before and after a subject gargled with mouthwash provided by the researcher. The entire protocol of this study was reviewed and approved by the Research Ethics Committee of the Faculty of Dentistry, University of Indonesia. The sample comprised 40 people who were chosen randomly, met all the criteria for inclusion, and were exempted from the exclusion criteria. The 40 subjects were divided evenly into two groups: the test group, which was required to rinse with mouthwash containing ClO_2 (i.e., Oxyfresh® "Oxygene® Mouthrinse"), and the control group, which was required to rinse with aquadest.

One day prior to the measurement, the subjects were instructed not to consume pungent foods to prevent overload levels of VSC. All subjects were also instructed not to eat, drink, gargle, brush their teeth, and consume chewing gum for at least 2 h prior to the initial measurements to obtain an initial score that was not too diverse among subjects. To eliminate the psychological factors that could become confounding factors in the study, the subjects were not told to which group they would be included prior to the measurement. The Oxyfresh® "Oxygene® Mouthrinse" used in this study was non-colored and clear, similar to aquadest, so that the subjects would be unaware of the type of mouthwash they would use.

The VSC scores were measured by OralChroma™, and organoleptic measurement was performed at 0 min before the subjects gargled (baseline), 30 min after the subjects gargled, 2 h after the subject gargled, 4 h after the subject gargled, and 6 h after the subject gargled.The VSC scores were analyzed by the Wilcoxon statistical test. A significance level of 0.05 ($p = 0.05$) and confidence level of 95% ($\alpha = 0.05$) were obtained**.**

3. Results and Discussion

3.1 Results

The comparison of the measurement results of the VSC scores between the test group and the control group in each measurement period is presented in Figure 1. The comparison of the measurement results of each score of the VSC components, the H_2S scores, the CH_3SH scores, and the $(CH_3)_2S$ scores is illustrated in Figures 2, 3, and 4, respectively. The results of the organoleptic measurements in each group are shown in Figures 5 and 6.

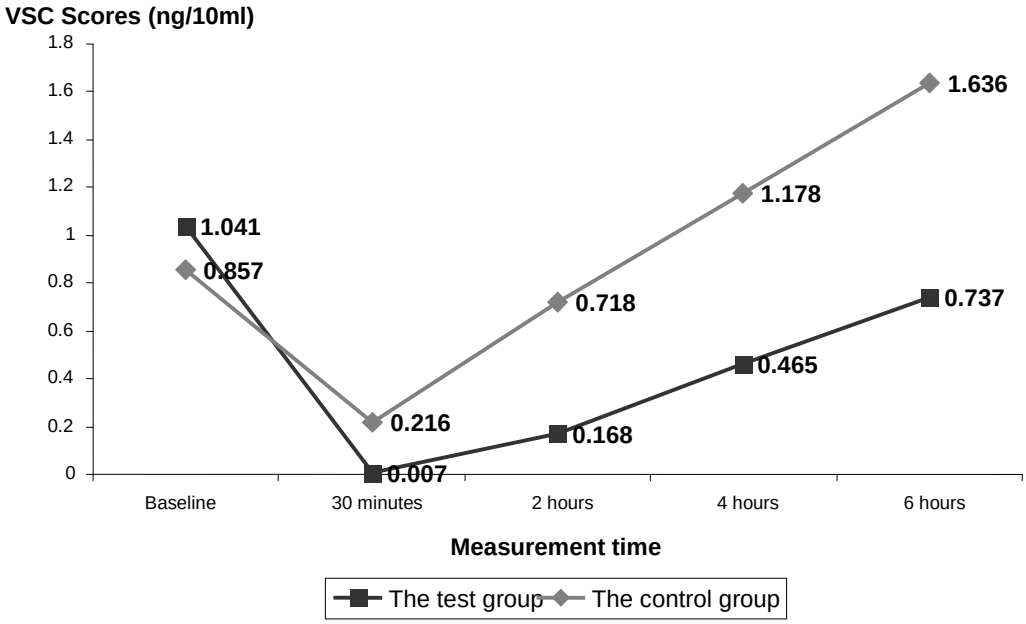

Figure 1. Comparison chart of the mean value of the VSC scores between the test group and the control group

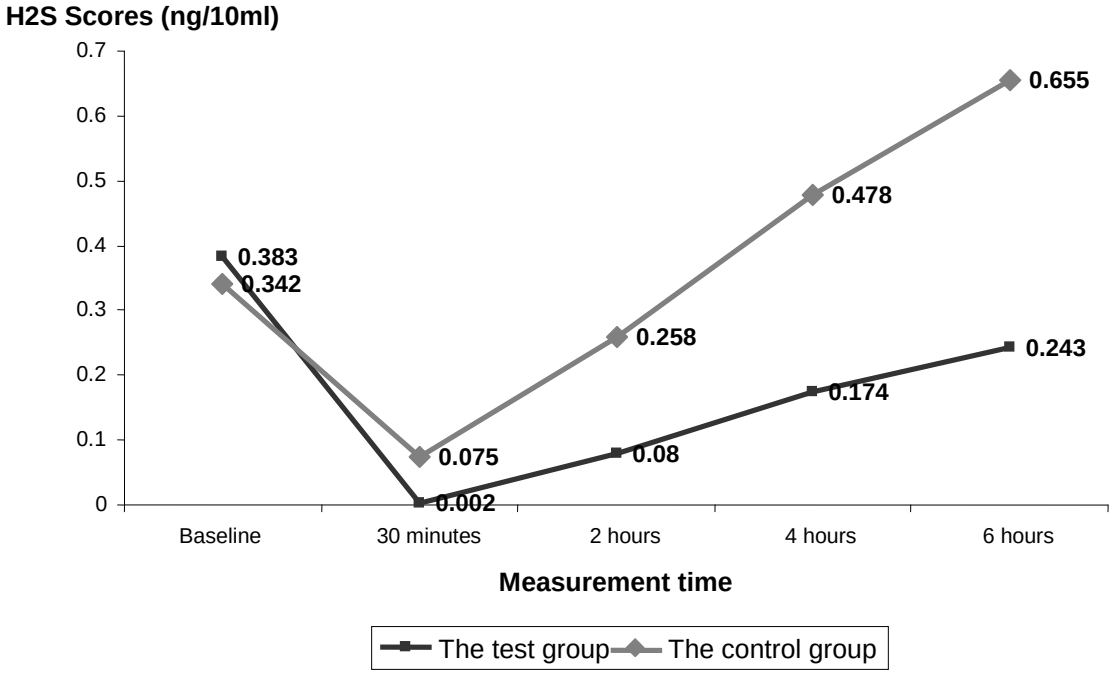

Figure 2. Comparison chart of the mean value of the H_2S scores between the test group and the control group

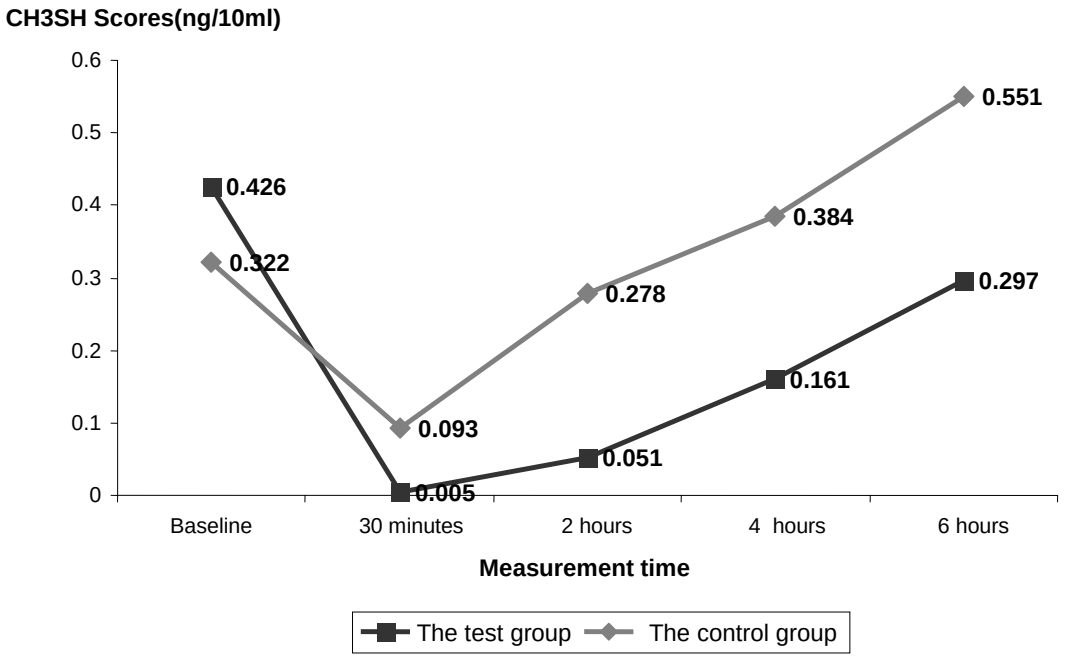

Figure 3. Comparison chart of the mean value of the CH_3SH scores between the test group and the control group

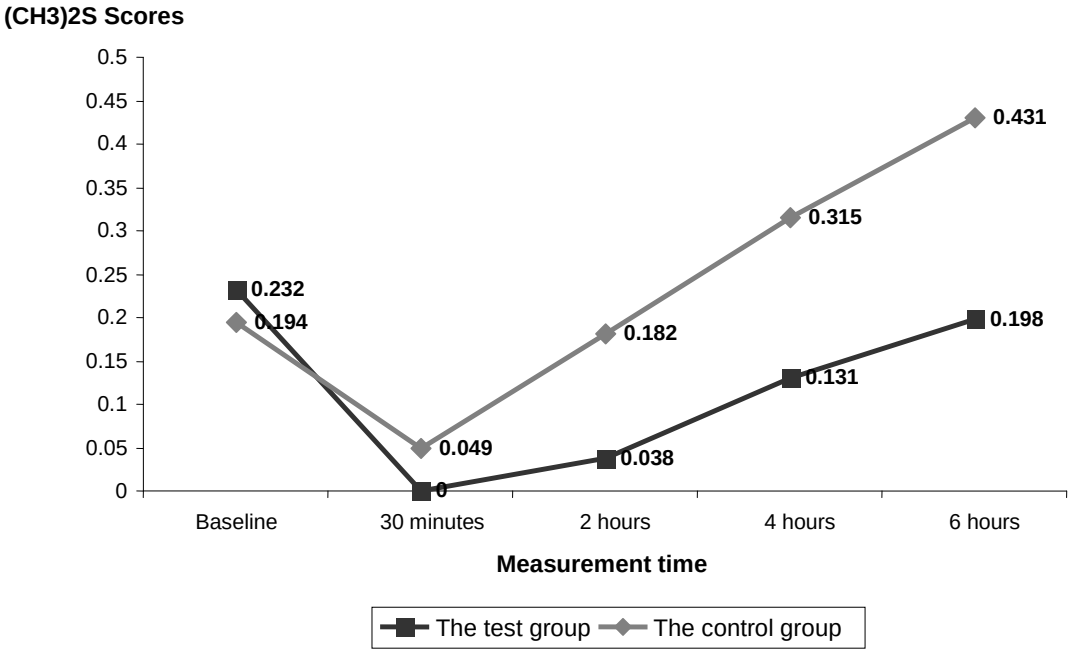

Figure 4. Comparison chart of the mean value of the $(CH_3)_2S$ scores between the test group and the control group

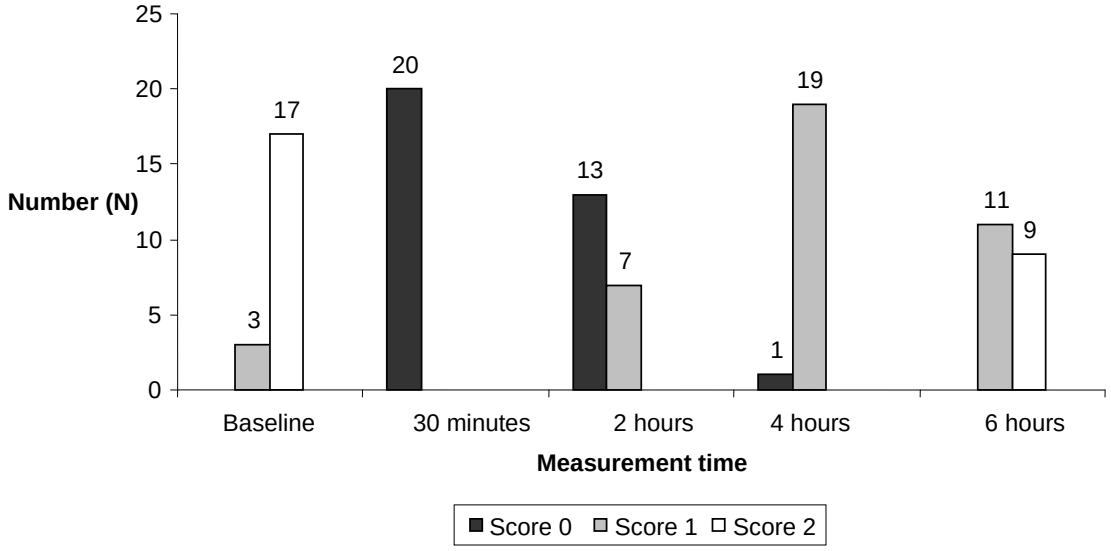

Figure 5. Diagram of the organoleptic scores in the test group

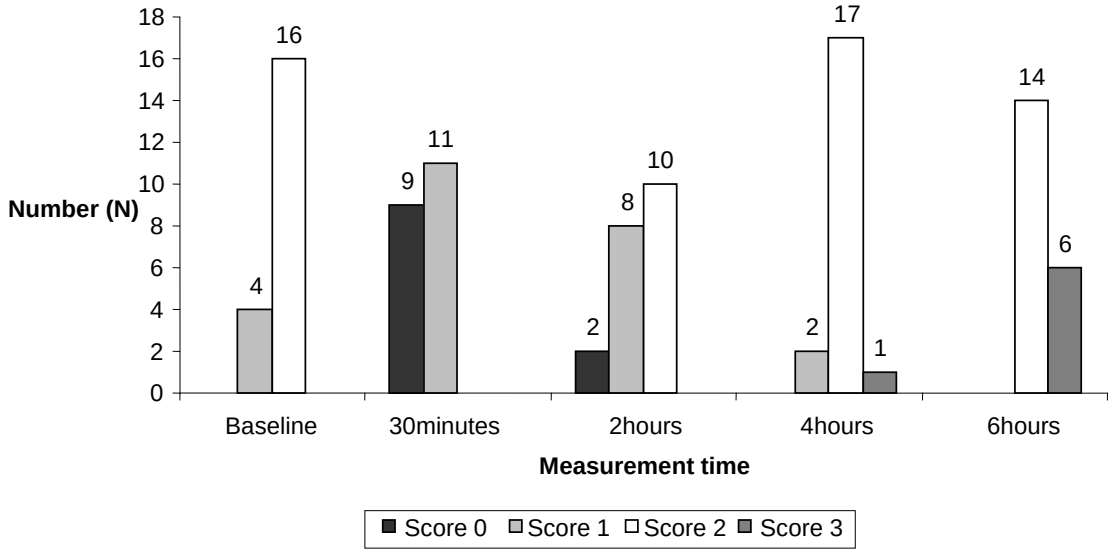

Figure 6. Diagram of the organoleptic scores in the control group

The p-value in the Wilcoxon test analysis showed no significant difference in the baseline measurement before gargling in the VSC, H_2S, CH_3SH, and $(CH_3)_2S$ scores between the test group and the control group ($p > 0.05$). In the measurement 30 min, 2 h, 4 h, and 6 h after gargling, the p value of the Wilcoxon test showed a significant difference in the VSC scores between the test group and the control group ($p < 0.05$).

3.2 Discussion

Measuring VSC with Oral Chroma has been widely used. The advantage of Oral Chroma are its compactness, and is able to measure individual VSC (H2S, CH3SH, and (CH3)2S) [9]. The results of

the VSC measurement by Oral Chroma after analyzing the Wilcoxon statistical test showed a significant difference in the VSC scores between the control group and the test group 30 min, 2 h, 4 h, and 6 h after treatment. In the initial measurement prior to the treatment or the baseline measurement, no significant difference was observed between the control group and the test group. The mean value of the VSC scores in the test group 30 min after gargling was only 0.007 ng/10 ml and that in the control group was 0.09 ng/10 ml. At 2 h after gargling, the mean value of the VSC scores was 0.168 ng/10 ml in the test group and 0.718 ng/10 ml in the control group. At 4 h after gargling, the difference in the mean value of the VSC scores was significant at 0.465 ng/10 ml in the test group and 1.178 ng/10 ml in the control group. At 6 h after gargling, the mean value of the VSC scores was 0.737 ng/10 ml in the test group and 1.636 ng/10 ml in the control group; the mean value of the control group was two times greater than that of the test group. The scores of each component of VSC, namely, the H_2S, CH_3SH, and $(CH_3)_2S$ scores, also showed a statistically significant difference between the test group and the control group at 30 min, 2 h, 4 h, and 6 h after treatment. The baseline measurement of the H_2S, CH_3SH, and $(CH_3)_2S$ scores showed no significant difference between the test group and the control group.

VSC compounds are produced by gram-negative anaerobic bacteria that exist in the oral cavity [14]. Silwood *et al*. [17] and Al-Bayaty *et al*. [11] found that ClO_2 interacts with bacteria-specific biomolecules and disrupts the physiological functions of microorganisms through the reactions between the organic substances of bacterial cell wall with ClO_2, which damages the cell membranes of bacteria that produce VSC. The function of the bacterial cell membrane is to maintain the integrity of the overall contents of the cytoplasm and selectively controls the transport of nutrients to cells; therefore, damage to a cell membrane of bacteria can cause bacterial death [11,16]. Silwood also observed that ClO_2 could penetrate into the bacterial cell wall and react with vital amino acids in the bacterial cytoplasm, thus killing the bacteria [17].

The results of the study by Taiyeb-ali *et al*. [20] strengthened those of the study by Chapek [18], who found that the oxygen produced by ClO_2 could maintain the amount of oxygen in the saliva and gingival sulcus [18]. Anaerobic bacteria cannot survive with the presence of oxygen in the saliva and gingival sulcus [19-20]. This condition delays the formation of VSC in the oral cavity. In addition, the oxygen contained in ClO_2 is one of the sources of antioxidants that can be used in the treatment of periodontal diseases, as oxygen can increase the metabolic process and thus enhance immunity by reducing the free radicals that cause inflammation [21-22].

Similar to the measurement of VSC compound with oral chromatography, the results of the organoleptic measurement at 30 min, 2 h, 4 h, and 6 h after the treatment also showed a significant difference between the control group and the test group. Based on the results of the VSC scores measured by Oral Chroma and the organoleptic scores measured by the sense of smell, the increase in VSC scores was directly proportional to the increase in organoleptic scores. Therefore, the higher the level of VSC in the oral cavity is, the more pungent the smell of the oral cavity is perceived.

Previous study found that ClO_2 mouthwash was effective in inhibiting the formation of plaque. Moreover, research on the antibacterial effect of ClO_2 indicated that ClO_2 gel had a stronger antibacterial effect against dental biofilm than hyaluronic gel and chlorhexidine, thus making it an alternative therapy in dentistry [11,19]. The results of this study proved that ClO_2 is an oxidizing agent with a strong antibacterial effect, thus making it effective in reducing the number of VSC and as a masking agent against halitosis. Mouthwashes containing ClO_2 can be used in dentistry as an antibacterial to effectively reduce halitosis

4. Conclusion

Gargling with mouthwash containing ClO_2 is effective against halitosis in the capacity of lowering the levels of the VSC components, namely, H_2S, CH_3SH, and $(CH_3)_2S$, in the oral cavity. Unlike in the control group, the test group indicates that gargling with mouthwash containing ClO_2 is effective in reducing halitosis.

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