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ORIGINAL ARTICLE

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Effect of Polyethylene Terephthalate Tongue Scraper on Oral Levels of Volatile Sulfur Compounds: a randomized clinical trial

Efeito do raspador de língua de polietilenotereftalato nos níveis orais de compostos sulfurados voláteis: um ensaio clínico randomizado

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ABSTRACT

Objective: To evaluate the effect of Polyethylene Terephthalate (PET) tongue scraper on the volatile sulfur compound (VSC) levels. **Material and Methods:** A randomized, controlled, parallel design was used in this study. Out of the 48 volunteers from Dentistry Department of the Federal University of Sergipe, 40 subjects who met the inclusion criteria were randomly divided into 4 groups (n=10): G1 (control), rinsing of distilled water solution (WS); G2, WS and tongue coating removal (TCR) with toothbrush; G3, WS and TCR with a commercial tongue scraper; and G4, WS and TCR with PET tongue scraper. PET bottles were cut with a rectangular shape (1.0 cm wide x 20 cm long) to obtain PET tongue scraper. The VSC measurements were performed before (T0) and immediately after (T1) each therapy by portable sulfide monitor. Data (ppb) were submitted to Wilcoxon test (α=0.05). The differences between T0 and T1 were calculated and percentage values were assigned. Data (percentage) were submitted to ANOVA and Tukey test (α=0.05). **Results:** All 40 selected subjects completed the study. All groups reduced significantly the VSC levels after therapy (P<0.01). ANOVA indicated a significant difference among groups (P<0.001). The Tukey test showed that G1 (reduction of 21%) was similar to G2 (31%); G2 was similar to G3 (42%) and different from G4 (52%); G3 and G4 were similar. **Conclusion:** PET tongue scraper was similar to commercial tongue scraper and provided higher reductions of VSC levels than the toothbrush.

KEYWORDS

Halitosis; Polyethylene terephthalates; Sulfur compounds; Tongue.

RESUMO

Objetivo: Avaliar o efeito do raspador de língua de polietilenotereftalato (PET) nos níveis de compostos sulfurados voláteis (CSVs). **Material e Métodos:** Um desenho paralelo, controlado e randomizado foi empregado neste estudo. Dos 48 voluntários do Departamento de Odontologia da Universidade Federal de Sergipe, 40 atenderam ao critério de inclusão e foram distribuídos aleatoriamente em 4 grupos (n=10): G1 (controle), bochecho com solução de água destilada (SA); G2, SA e remoção da saburra lingual (RSL) com escova dental; G3, SA e RSL com um raspador de língua comercial; e G4, SA e RSL com raspador de língua PET. Garrafas PET foram recortadas com uma forma retangular (1,0 cm de largura x 20 cm de comprimento) para obtenção dos raspadores de língua PET. As mensurações de CSVs foram realizadas antes (T0) e imediatamente após (T1) cada terapia usando um monitor portátil de enxofre. Os dados (ppb) foram submetidos ao teste de Wilcoxon (α=0,05). As diferenças entre T0 e T1 foram calculadas e transformadas em valores percentuais de redução. Os dados (percentuais) foram submetidos à ANOVA e ao teste de Tukey (α=0,05). **Resultados:** Todos os 40 indivíduos selecionados completaram o estudo. Em todos os grupos houve redução significante dos níveis de CSVs após terapia (P<0,01). ANOVA indicou uma diferença significante entre grupos (P<0,001). O teste de Tukey mostrou que G1 (redução de 21%) foi semelhante a G2 (31%); G2 foi semelhante a G3 (42%) e diferente de G4 (52%); G3 e G4 foram semelhantes. **Conclusão:** O raspador de língua PET foi semelhante ao raspador de língua comercial e proporcionou maiores reduções de CSVs do que a escova dental.

PALAVRAS-CHAVE

Halitose; Polietilenotereftalatos; Compostos de Enxofre; Língua.

INTRODUCTION

Halitosis, also known as bad breath or malodor oral, is an unpleasant odor exhaled from the oral cavity [1-4]. Although there are several extra-oral causes for the breath changes, about 80% to 90% of the halitosis cases are associated with the mouth [1]. The volatile sulfur compounds (VSCs) are primarily responsible for intra-oral halitosis: hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), and dimethyl sulfide [$(CH_3)_2S$] [5,6]. The VSCs result from the proteolytic degradation of sulfur-containing substrates [2,7,8] promoted by anaerobic gram-negative microorganisms as *Fusobacterium nucleatum* [7,8], *Porphyromonas gingivalis*, *Tannerella forsythia* [1-4], and *Treponema denticola* [2]. The posterior region of the tongue dorsum is the main source of the VSCs, since this area is favorable to accumulate exfoliated (desquamated) epithelial cells, saliva, bacteria, blood metabolites, and food debris, which form the tongue coating [5,6,9]. There is a positive correlation between the tongue coating amount and the VSC concentrations [10].

A number of different monitoring methods are available to detect halitosis [11]. The organoleptic measurement is the most popular diagnostic method, which is a sensory test scored by a trained odor judge of the patient's oral and nasal exhaled air [1,3,12]. Despite the test subjectivity because it depends on examiner olfactory acuity [11], this method is considered the gold standard for the halitosis diagnosis in clinical practice [1]. Nevertheless, the organoleptic method has disadvantages such as absence of reproducibility and reliability, indicating the difficulty to use this method in research [12]. Since VSCs are known to be important contributors for halitosis, their measurements could provide a quantitative and objective method to halitosis assessment [12]. Gas chromatographs are able to determine the quality and quantity of VSCs, but these devices has higher cost and demand more complex operating procedures than sulfide monitors [11,12]. Although the gas chromatographs have been recommended as standard for clinical researches of halitosis, portable gas chromatographs such as OralChroma™ (Abilit, Osaka, Japan) or TwinBreasor™ (GC, Tokyo, Japan) have been considered acceptable [13]. Portable sulfide monitors such as Halimeter® (Interscan Corporation, Chatsworth, USA) [11,12,14,15], Breathtron® (New Cosmos Electric, Osaka, Japan) [16], Breath AlertTM (Tanita Corporation, Tokyo, Japan) [17-19] have been employed in researches because they are less expensive and easy-to-use tests [11]. Currently, among instrumental detection methods for VSCs, the Halimeter® (Interscan Corporation) and the OralChroma™ (Abilit) have been the devices recommended [1] because both showed acceptable correlations with calibrated odor judges [20].

The tongue coating removal reduces the VSC levels [2,4,14,16-18,21] because it seems to reduce the substrata for putrefaction by bacterial [22]. Therefore, as well as mouthwashes, devices developed for tongue cleaning are recommended as home-based oral hygiene measures for treatment of intra-oral halitosis [1,4,23]. These devices have been called tongue scrapers or tongue cleaners, which have been made of materials such as plastic or metal, with different designs [5,24]. The toothbrushes can also be used for tongue cleaning [5], but they have been less effectiveness than tongue scrapers [14,17], producing gagging reflex during their use [22]. Although several tongue scraper designs are commercially available [5,24], an alternative tongue scraper, made from bottle containers of Polyethylene Terephthalate (PET), could contribute for environmental sustainability by recycling of plastic bottles. Therefore, the purpose of this study was to evaluate the effect of PET tongue scraper in the immediate production of the oral VSC levels after tongue coating removal, comparing to a commercial tongue scraper and a toothbrush. The null hypothesis was that the oral VSC levels immediately after tongue coating removal with PET tongue scraper would not be different compared to a commercially available tongue scraper and toothbrush.

MATERIAL & METHODS

This study was conducted in agreement with Declaration of Helsinki. Forty eight patients with an age of 18 to 60 years from Dentistry Department of the Federal University of Sergipe have enrolled to participate in this randomized clinical trial. The total VSC levels up to 50 parts per billion (ppb) [11] were adopted as inclusion criteria. The exclusion criteria included smoking, pregnancy, antibiotic treatment in the past 3 months, and individuals that drank alcoholic beverages on a regular basis. Sample size was determined with an expected mean difference of VSC levels of 11 ppb, a standard deviation of 67 ppb from a previous study [14], a 95% confidence level, and a power of 85%. The results indicate that 10 subjects in each group were required for the study. Forty adults (16 men, 24 women; range of age 20-57 years) met the inclusion criteria. Therefore, the study was explained to the subjects, who expressed their agreement by signing the informed consent approved by the Research Ethics Committee of the Federal University of Sergipe, by process number CAAE 36837314.2.0000.5546.

This study used a randomized, controlled, and parallel design. These volunteers were randomized into four groups by a computer-generated randomization system (n=10): G1 (control), rinsing 20 ml of distilled water solution (Distilled water for injection, Equiplex, Aparecida de Goiania, Goias, Brazil) for 1 min (WS); G2, WS and tongue coating removal (TCR) with toothbrush (Twister®, Colgate-Palmolive Co., Andean Region, Colombia); G3, WS and TCR with commercial tongue scraper (Tongue Cleaner Kolbe®, Kolbe, Salvador, Bahia, Brazil); and G4, WS and TCR with PET tongue scraper.

PET tongue scraper production

All PET tongue scrapers were produced by a single operator. Polyethylene Terephthalate is a plastic type known as PET or PETE, which is commonly used for water and soda bottle containers. The PET tongue scraper was obtained from 2 liters soda bottles. After cleaned with water and neutral detergent, the PET bottles were cut with a stainless steel scissor (multi-use scissor 160-8N, Mundial, Gravatai, Rio Grande do Sul, Brazil) in their central portion and to obtain each strip with a rectangular shape (dimensions of 1.0 cm wide and 20 cm long) a number 15 surgical blade (Carbon steel size 15 surgical blade, BD Bard-Parker, Franklin Lakes, New Jersey, USA) was used. The final step was to carefully examine the accuracy of edge trimming by visual and touch inspection, as the PET tongue scraper should not cause injuries for tongue surface. Therefore, the devices with irregular edges were excluded. The PET gives the device a suitable flexibility to allow that two ends could be joined and thus the curved portion could be used to remove the tongue coating. The PET tongue scrapers were disinfected by immersion in sodium hypochlorite solution 1% (Milton Solution–sodium hypochlorite 1%, Asfer Chemical Industry, Sao Caetano do Sul, Sao Paulo, Brazil) for 10 min, washed with water, dried with paper towel, and stored in sealed plastic bags.

Tongue coating removal

The tongue coating removal was performed by an operator previously calibrated using the three devices tested (Figure 1). For mechanical tongue cleaning a total of six strokes from posterior to anterior region of the tongue were performed, with two strokes in each part: left, middle, and right of the tongue posterior dorsum [21]. After the tongue coating removal, the volunteers were asked about discomfort as a burning tongue.

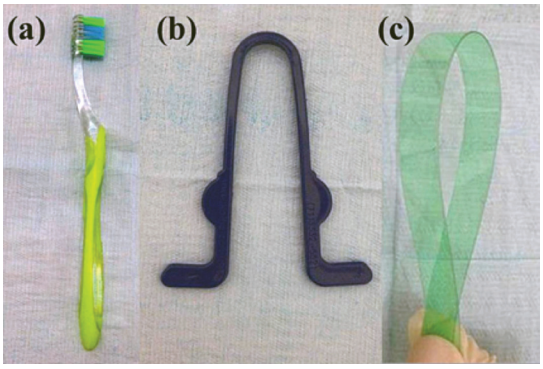


Figure 1 - Devices used to remove the tongue coating. (a), toothbrush – group G2; (b), commercial tongue scraper – group G3; and (c), PET tongue scraper – group G4.

VSC Measurements

The VSC measurements were performed in the morning using a portable sulfide monitor (Halimeter®, Interscan Corporation, Los Angeles, California, USA). For twenty-four hours before readings the individuals were asked to refrain from eating garlic, onion, spice; drinking coffee, alcoholic beverages, soft drinks; and to avoid using aromatic cosmetics such as perfumes, aftershave lotion, moisturizers creams, among others. The volunteers were asked to refrain from eating, drinking, chewing gum, and all oral hygiene practices from midnight until completing VSC measurements.

The individuals were instructed to close their mouths for 3 minutes to remain the mouth-breath sample. A straw connected to the reading device was then inserted 5 cm into the nearly closed mouth, which remained in this position without contact with oral tissues until the reading completion, when the peak value was recorded [12]. To standardize the readings, the operator placed a mark on a 5 cm-long straw using a permanent marker pen (CD Marker, Faber-Castell, Sao Carlos, Sao Paulo, Brazil). The subject was asked not to exhale or inhale and to breathe through his/her nose while the reading was collected. This procedure was performed three times at three-minute intervals and the average value was obtained. Two measurements were performed: before and immediately after each therapy.

Statistical Analysis

Data obtained in ppb before therapy (baseline) were submitted to the Kruskal-Wallis test ($\alpha=0.05$) to assess the similarity among the groups. For an intra-group analysis, data in ppb before (T0) and immediately after (T1) treatment were submitted to Wilcoxon test ($\alpha=0.05$). For evaluation among groups of the therapy effect, the difference data in ppb between T0 and T1 were transformed into percentage values (VSC reduction percentage values) and submitted to ANOVA and Tukey test ($\alpha=0.05$).

RESULTS

All 40 selected subjects, including 16 men and 24 women (range of age 20-57 years) completed the study. There was no dropout, since the measurements were performed in a single appointment. No adverse effects on tongue were observed by the dental examiner or reported by the participants throughout the study.

Because the distribution of the VSC level data in ppb was not normal, the statistical analysis was performed with non-parametric tests. The Kruskal-Wallis test showed similarity among groups for initial VSC levels (baseline) ($P>0.05$). For intra-group evaluation, the Wilcoxon test indicated significant reduction of VSC levels for all the groups immediately after therapy ($P<0.01$) (Figure 2).

Since the distribution of the reduction percentage data was normal, the ANOVA was performed. The ANOVA showed significant differences among the groups for VSC reduction percentage values (Table I) and the critical value of Tukey was calculated to indicate these differences (Figure 3).

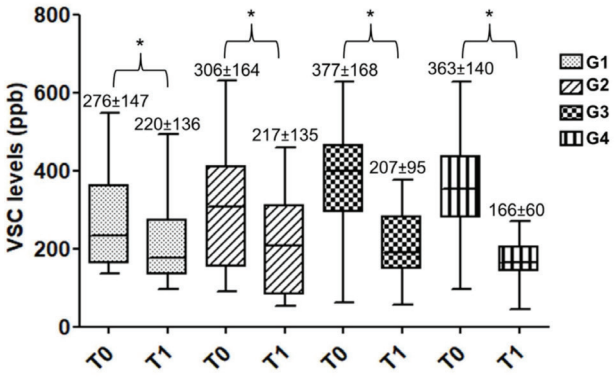


Figure 2 - Distribution of VSC levels between the times: before (T0) and immediately after (T1) therapy for each group - *(P<0.01).

Table I - Results of Analysis of Variance (ANOVA) 1-way.

Factors	Sum of Squares	df	Mean Square	F	P
Groups	5298.4727	3	2457.6104	8.14	<0.001
Residue	7811.30008	36	335.9524		
Total variation	13109.7734	39			

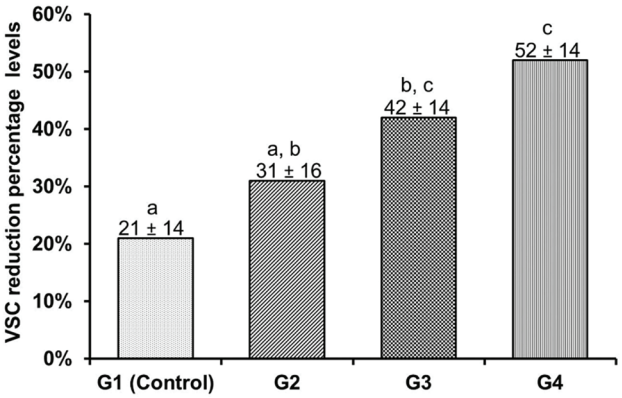


Figure 3 - Distribution of the VSC reduction percentage levels: groups with different letters are statistically different (P<0.05).

DISCUSSION

The results of the present study support rejection of the null hypothesis because the oral VSC levels immediately after tongue coating removal with PET tongue scraper was significantly decreased compared to toothbrush, but not significantly different compared to a commercially available tongue scraper. VSCs are important components of intra-oral halitosis, which are produced mainly at the tongue dorsum by bacterial degradation [1,2,5,6,9,10]. In the present study the Halimeter® (Interscan Corporation) was used to measure the total VSC concentrations, since it cannot distinguish the components of VSCs [12]. This device has been reported as objective method equivalent to organoleptic measurements [11,12,20]. In the present investigation, the VSC measurements were carried out in the morning after the volunteers have refrained from eating, drinking, oral rinsing, and oral-hygiene since midnight until the end of VSC readings, which were performed from 7 am to 9 am. Although previous studies have allowed for at least two hours [10,12,16], one hour and thirty minutes [18], or three hours prior to examination [15], Yaegaki et al. [13] have recommended more than six hours.

Chemical and mechanical methods are available for controlling VSCs from tongue coating [15-19,21,23]. The toothbrush and tongue scrapers have been the mechanical devices recommended for tongue coating removal [5,22]. In this study, all therapies provided a significant reduction of the VSC levels when compared to baseline (Figure 2). In the control group (group G1), although the distilled water solution has no chemical action on the tongue coating, it is possible that the mechanical action caused by the liquid agitation during the rinsing has removed part of tongue coating, providing a significant reduction of VSC levels (Figure 2). Despite wide range of threshold limits proposed as indicative of halitosis when the Halimeter® (Interscan Corporation) is used [11,20], halitosis becomes perceptible between 50 and 150 ppb [11]. According to manufacturer instructions, readings with range of 80-140 ppb are considered for subjects with no oral malodor. Thus, the manufacturer recommends a value of 150 ppb as limit for social acceptance [20]. Nevertheless, considering a 150-ppb limit, VSC levels remained elevated after the therapies in this study (Figure 2). The mean VSC levels observed in this study for the devices evaluated (217 ± 135 ppb for toothbrush, 207 ± 95 ppb for commercial tongue scraper, and 166 ± 60 ppb for PET tongue scraper) were higher than those reported in previous investigation immediately after tongue cleaning (133 ± 68 ppb for toothbrush, and 122 ± 67 ppb for scraper tongue) [14], which also used the portable sulfide monitor Halimeter® (Interscan Corporation) as in the present study. This result could be explained by the number of the strokes from the back to the tip of the tongue, as six in the present study design compared to ten evaluated by Seeman et al. [14].

In this experiment, the toothbrush (group G2) showed a result similar to rinsing with distilled water (group G1 - control) and commercial scraper tongue (group G3) (Figure 3). These findings differ from previous investigations [14,17,23], which observed for commercial tongue scraper significantly lower VSC levels than for toothbrush. However, these results reported by authors [14,17,23] are consistent with those obtained in this study for PET tongue scraper (group G4), which provided

significantly higher percentage reductions of VSC levels than toothbrush (Figure 3). Notwithstanding, the investigations of Patil et al. [23] were carried out on children by an organoleptic method for detection of halitosis, whereas in the present study the volunteers were adults evaluated by an instrumental detection method for VSCs. Although Pedrazzi et al. [17] have used the same commercial tongue scraper evaluated in this study, the toothbrush design was different. Additionally, these authors performed the measurements of VSC levels by Breath AlertTM (Tanita Corporation) [17], which is a portable sulfide monitor different from used in this investigation. Seemann et al. [14] also performed the measurements of VSC levels using Halimeter® (Interscan Corporation) as in this study, but the tongue scraper and the toothbrush designs evaluated in their investigations were different those evaluated in the present study. Therefore, these differences may have contributed to this divergence of results.

The PET tongue scraper (group G4) was similar to commercial tongue scraper (group G3) (Figure 3). This result could be explained by the plastic type from PET tongue scraper, which probably has provided its edge rigidity similar to the commercial tongue scraper, promoting proper tongue coating removal. Tongue cleaners vary in shape, size, quality of contact surfaces and materials used to make them, altering their effectiveness during tongue scraping [24]. In present study the tongue coating removal was performed by a professional as investigation previous [14], but other authors have evaluated tongue cleaning methods when the volunteers have carried their tongue coating removal [15-19,22,23]. Nevertheless, a priori design study, based on tongue coating removal performed by a professional, should be indicated to evaluate a new device as the PET tongue scraper. Considering the absence of adverse effects in the present study after a single cleaning of the tongue performed by professional, the evaluation of the PET tongue scraper as home-based oral hygiene measures by user could be performed in future investigations. However, concerns have been raised in regarding to a regularly performed mechanical tongue cleaning and the possible injury for tongue surface [1]. In previous investigation [17], one subject showed a small amount of tongue trauma induced by one week using toothbrush to remove the tongue coating. Currently, randomized controlled clinical trials evaluating tongue cleaning by user have been performed for periods ≤ 3 weeks follow-up [14-18,21,22]. Consequently, the potential for adverse effects with long-term tongue scraping should be set, through data concerning the use of the toothbrushes and different designs of the tongue scrapers, including the PET tongue scraper and all the tongue scrapers commercially available. Therefore, in order to avoid unnecessary tissue trauma the patients should be instructed thoroughly to carry out gently the tongue cleaning with low force [1].

The tongue coating removal with PET tongue scraper significantly reduced the VSC levels (Figure 2), producing similar results to commercial tongue scraper and significantly higher percentage reductions of VSC levels than the toothbrush (Figure 3). This finding of the present study may be significant, considering factors related to PET tongue scraper. It could be less expensive because the manufacturers could recover PET bottles from a waste stream for reuse. In addition, the use of a recyclable material could contribute for environmental sustainability.

Considering the design of this study, it was difficult to compare the results of this experiment with those obtained in other studies, since different devices have been used to measure the VSC levels [16-19,21], and different tongue scraper designs have been evaluated [14,15,21,23]. Additionally, in the present study the results were obtained after a single tongue coating removal carried by professional and different findings could be observed when the ordinary users remove their tongue coating. Thus, the results obtained cannot be directly interpreted as relevant for home-based oral hygiene measures. Therefore,

further investigations are needed to evaluate the PET tongue scraper for tongue coating removal when performed by subjects and their perception about efficiency, gagging, and comfort. Moreover, the potential for adverse effects with long-term tongue scraping using the PET tongue scraper should be set.

CONCLUSION

Within the limitations of this study, it was concluded that all devices used for the tongue coating removal were able to reduce the VSC oral levels. The PET tongue scraper was similar to the commercial tongue scraper and produced higher reductions of VSC levels than the toothbrush.

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