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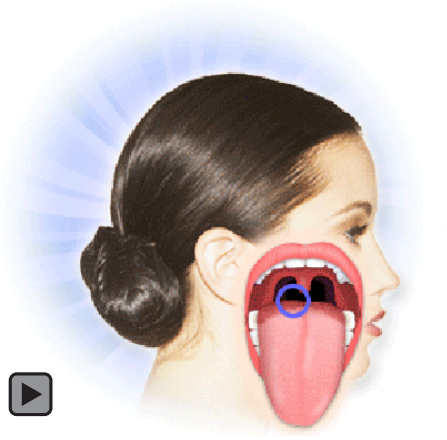
Short-term Effects of a Combination Product Night-time Therapeutic Regimen on Breath Malodor

Svetlana Farrell, DDS, PhD; Matthew L. Barker, PhD;
Amy Walanski, BS; Robert W. Gerlach, DDS, MPH



Aim: To evaluate the malodor reduction benefits of a therapeutic night-time oral hygiene regimen that combined antibacterial toothpaste and mouthrinse with an oscillating-rotating rechargeable power toothbrush.

Methods and Materials: An independent clinical trial was conducted using a randomized, negative-controlled, single blind, two treatment, 4-period crossover design. After completing a 1-week acclimation period, subjects were randomly assigned to a treatment sequence consisting of the following two regimens: (1) a night-time regimen of Crest® Pro-Health® Night dentifrice, Crest® Pro-Health® Night rinse, and Oral-B® Vitality™ Precision Clean™ power toothbrush and (2) a control regimen of Crest® Cavity Protection dentifrice and an ADA manual toothbrush. Each treatment period started with an overnight baseline volatile sulfur compounds (VSCs) Halimeter® measurement, followed by twice daily use of the assigned regimen. Post-treatment overnight malodor was assessed at 24 hours. There were 2-day washout periods between treatments. All procedures were repeated with the next assigned regimen, through four crossover periods.

Results: Twenty-five subjects completed the study. Twice daily use of the therapeutic night-time regimen resulted in a significant (p>0.001) 35% reduction of mean VSC levels in the overnight breath compared to the control regimen.

Conclusion: One-day use of a night-time regimen consisting of a therapeutic paste, rinse, and an oscillating-rotating rechargeable power toothbrush provided a 35% reduction in overnight breath malodor compared to regular brushing.

Clinical Significance: Combining a proven therapeutic dentifrice, mouthrinse, and advanced design toothbrush in a single regimen is an efficient means of maximizing breath odor reductions.

Keywords: Breath odor, malodor, stannous fluoride, sodium hexametaphosphate, CPC rinse, Halimeter, volatile sulfur compounds, VSCs, regimen, power toothbrush, randomized clinical trial

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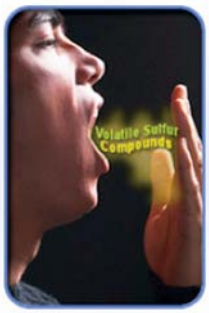
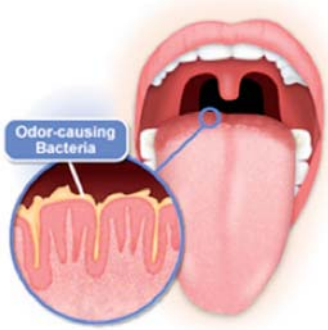
Introduction

Throughout history, maintaining socially acceptable breath aroma has been desirable. Fair or not, detecting objectionable breath in an individual may cause others to ascribe negative perceptions regarding hygiene level and even personal value.[1] With today's high expectations for cosmetic appearance and cleanliness, it's not surprising that perceived bad breath can potentially lead to impaired self worth and social isolation if untreated.[2]



The etiology of breath odor is multi-factorial, infrequently stemming from naso-pharyngeal infection, systemic conditions, or medication-induced sources.[3] Myriad research, however, has demonstrated the principal causal factors emanate locally from within the oral cavity and account for up to 90% of all malodor cases.[4,5] Breath odor occurs predominately with the exhalation of volatile sulfur compounds (VSCs) like methyl mercaptan and hydrogen sulfide, generated from gram-negative anaerobic bacteria associated with gingivitis and periodontal disease.[3] The most common oral reservoir of these bacteria is the posterior region of the tongue, where its morphology predisposes it to bacterial putrefaction.[3,6] Research has also linked oral malodor to periodontal disease.[7] Transient, non-pathogenic breath odor can be generated by eating odorous foods or after sleeping when saliva production is reduced ("morning breath"). At night, low salivary flow creates a favorable environment for bacterial proliferation and plaque accumulation on the dorsum of the tongue and the surface of the teeth resulting in higher levels of VSC in the morning.



Morning breath is reported to be a common "breath" complaint and can be improved by oral hygiene means.[7,8] Estimates also show perhaps one-quarter of all adults suffer from halitosis,[7] and if aware of the problem,[9] are often motivated to improve their oral hygiene and seek out effective treatments. In response, a thriving industry marketing breath improvement aids has developed. Some products are strictly breath fresheners (e.g., gum, mints, sprays) and provide a temporary 'masking' effect but don't address the underlying cause.[10] On the other end of the spectrum are chemical agents such as antibacterial toothpastes and mouthrinses and mechanical tools like toothbrushes and tongue cleaners. Specifically formulated to combat the bacterial sources promoting breath odor, some have published clinical research supporting efficacy. Few have been evaluated in combination with another product or regimen, however, when in reality this may be how patients – seeking the greatest benefit – likely use them.

Various methods have been used to diagnose oral malodor and estimate its degree.[3,11-14] Approaches include breath assessments by qualified judges (organoleptic intensity and hedonic scales), analyzing for presence and concentration of certain components of oral malodor (gas chromatography, halimetry, and sensor arrays), and detecting bacteria associated with oral malodor and their metabolites (BANA test, ammonia monitoring, and β-galactosidase test). Each method has its own advantages and disadvantages. For instance, while organoleptic measurements are generally considered as a standard for oral malodor assessment some criticize its subjectiveness and question reproducibility. Gas chromatography has been advocated as a comprehensive, objective, and reproducible method of quantitative assessment of oral malodor. However, the high instrument cost, need for extensive operator training, and long measurement time make it impractical for most clinical applications. A portable sulfide monitor – Halimeter – has been commonly used in clinical research, breath clinics, and dental practices as a practical way to quantitatively measure VSCs of oral malodor. Despite its limitations of not measuring the entire spectrum of oral odorants and potential interference from other volatile compounds in ambient air, Halimeter has been a method of choice for many researchers and practitioners because of its high throughput, ease of use, and relative reproducibility. VSC levels measured by Halimeter were reported to be correlated with the organoleptic scores and measurements obtained by gas chromatography.[12,15-18]

The aim of this clinical trial was to assess the overnight malodor reduction benefits of a therapeutic night-time oral hygiene regimen that combined an antibacterial toothpaste, an antibacterial mouthrinse, and an oscillating-rotating power toothbrush designed for enhanced plaque control.

Methods and Materials

An independent clinical study examined the overnight breath odor benefits of a night-time oral hygiene regimen combining an antimicrobial dentifrice and rinse with an oscillating-rotating rechargeable power toothbrush. The trial was conducted using a randomized, negative-controlled, single-blind, two-treatment crossover design of four treatment periods approximately 24 hours each.

Study Population

Study participants were selected from an existing malodor panel. The malodor panel consisted of subjects who had previously shown reproducible levels of VSC in their overnight breath as measured by a Halimeter. A total of 28 generally healthy adults were enrolled after providing informed consent. Qualified participants met the following entrance criteria:

- Were at least 18 years of age;
- Had at least 20 natural teeth;
- Agreed to avoid elective dentistry and prophylaxis during the trial;
- Agreed not to use any non-study oral care products for the duration of the study.

Subjects were excluded from the study if they used an antibiotic medication or a prescription mouthrinse within two weeks of the study baseline measurement.

Study Design

Subjects first participated in a one-week unsupervised acclimation period, wherein they set aside their normal oral hygiene routine and brushed for two minutes twice daily with 0.243% sodium fluoride Crest® Cavity Protection dentifrice (Procter & Gamble, Cincinnati, OH, USA) and an ADA reference manual soft toothbrush. Subjects were instructed to abstain from tongue brushing and flossing for the entire duration of the study. Subjects were reminded to use their acclimation products prior to 11:00 pm on the evening preceding their baseline visit.

To avoid potential malodor measurement confounders, subjects were cautioned to avoid the following prior to study baseline and all subsequent visits:

- Eating, drinking, performing oral hygiene, smoking, or using breath mints, lozenges, or chewing gum after the evening product use before a study visit.
- Consuming alcohol, highly seasoned foods, or foods associated with oral malodor (e.g., garlic, onions) within 24 hours before a study visit.
- Wearing perfume, powder, aftershave, or any other scented products on the malodor assessment days.

Each treatment period consisted of a baseline and a 24-hour overnight assessment of VSCs via the Halimeter® (Interscan Corporation, Chatsworth, CA, USA). At baseline of treatment period 1, participants were randomly assigned to one of four crossover treatment sequences, AABB, BBAA, ABBA, or BAAB, where A was a night-time regimen of Crest® Pro-Health® Night dentifrice (Procter & Gamble, Cincinnati, OH, USA)

containing 0.454% stannous fluoride and sodium hexametaphosphate, Crest® Pro-Health® Night rinse (Procter & Gamble, Cincinnati, OH, USA) containing 0.07% cetylpyridinium chloride (CPC), and Oral-B® Vitality™ Precision Clean™ power toothbrush (Procter & Gamble, Cincinnati, OH, USA) with a built-in 2-minute timer and B was a control regimen of Crest Cavity Protection (Procter & Gamble, Cincinnati, OH, USA) dentifrice and an ADA reference manual toothbrush. Regimen details are provided in Table 1.

Table 1. Treatment regimens.

	Pro-Health Regimen	Control Regimen
Products	1. Crest® Pro-Health® Night dentifrice (0.454% stannous fluoride and sodium hexametaphosphate) 2. Crest® Pro-Health® Night mouthrinse (0.07% CPC[a]) 3. Oral-B® Vitality Precision Clean rechargeable rotation-oscillation power toothbrush with Oral-B® Precision Clean brush head	1. Crest® Cavity Protection dentifrice 2. ADA reference manual soft toothbrush
Instructions	1. Brush teeth thoroughly for 2 minutes twice day, using the timer on the power toothbrush. 2. Rinse with 20 mL of the mouthrinse for 30 timed seconds.	1. Brush teeth thoroughly for 2 timed minutes and expectorate.

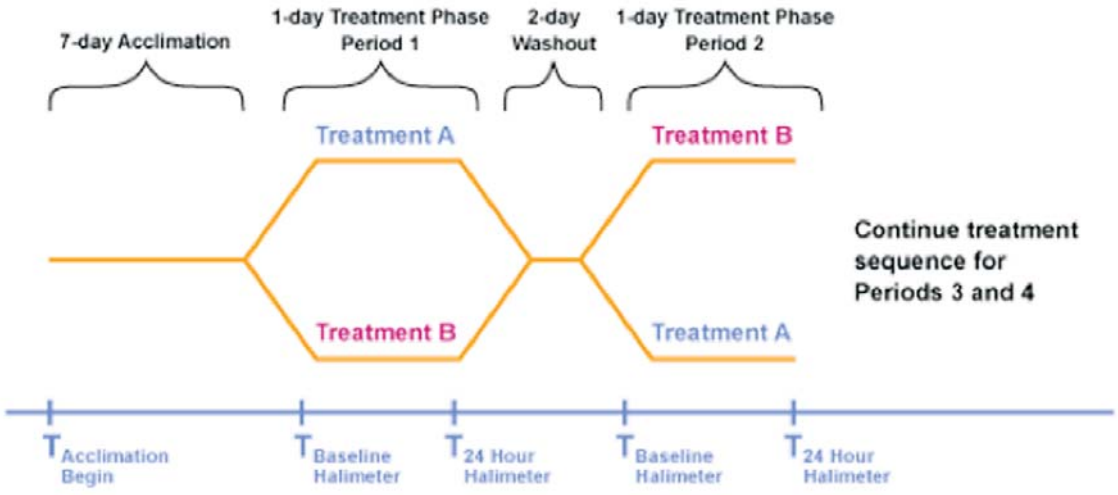


Figure 1. Study design.

Following the baseline Halimeter assessment, subjects used their assigned test products (overlabeled for blinding purposes) under supervision. Subjects were dismissed with their test products and instructed to follow their assigned regimen that evening at home prior to 11:00 pm. Subjects were reminded to observe eating, drinking, and brushing restrictions after the evening brushing prior to the next visit and to abstain from tongue brushing and flossing for the duration of the trial. At approximately 24 hours post-baseline, subjects returned for a Halimeter assessment representing the "overnight" time point.

At the end of each treatment period, test products were collected and all subjects entered a 2-day washout phase to prevent product carryover effects. Subjects used their acclimation products during the wash-out periods. After completing the four test periods and corresponding washout phases, subjects were dismissed from the study. Any adverse events reported by the subjects during the course of the study were appropriately recorded.

Breath Odor Measurement

Levels of VSC emissions were quantified in parts per billion (ppb) using a commercially available portable pre-calibrated Halimeter, operated by a trained technician. This instrument, shown in Figure 2, is sensitive to the chief malodorants of halitosis, including hydrogen sulfide and methyl mercaptan.

At each assessment, subjects were instructed to keep their mouth closed for two minutes and not to swallow during this time. The subject then placed his/her mouth around a clean cylinder connected to the instrument. While the subject held his/her breath, the instrument drew air from the mouth (without touching the subject's mouth) and the VSC concentration was recorded.

Figure 2. Halimeter assessment.

To view the video, please go to the online article at www.thejcdp.com

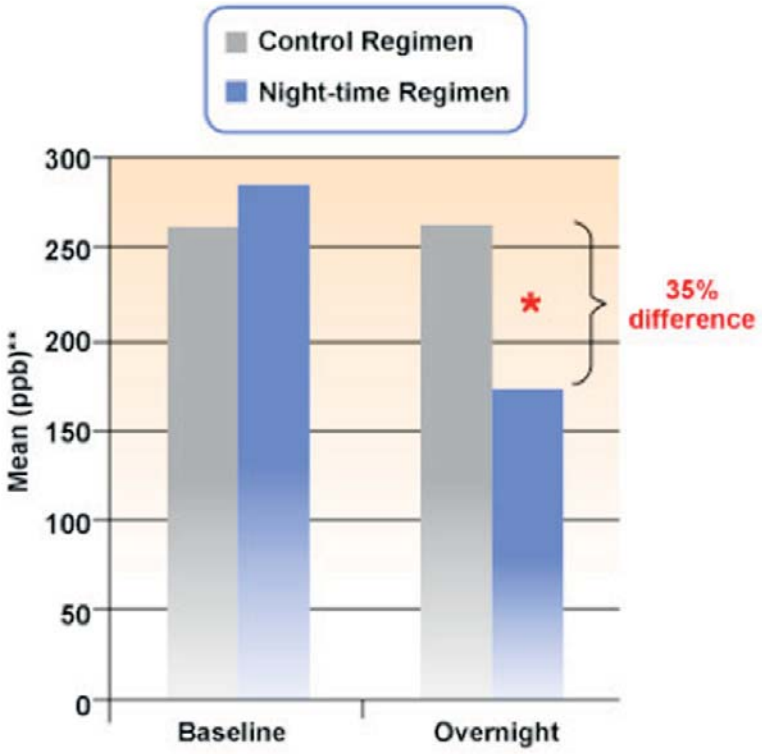
Statistical Analysis

Halimeter VSC data were analyzed on the natural logarithm scale, and mean results were transformed back to the original scale. Treatment effects were determined for each post-baseline evaluation point using analysis of covariance (ANCOVA) for a crossover design with subject period and treatment as factors and with baseline VSC as a covariate. The carry-over effect was not significant and was eliminated from the final statistical model. Comparisons were two-sided at the 0.05 level of significance.

Results

Twenty-five subjects completed the study and were deemed evaluable for analyses. Subjects ranged in age from 27-60 years (mean 42.1 years) and 60% were female. Treatments were balanced (p=0.245) with respect to baseline VSC with adjusted means ± standard errors on the natural log scale of 5.66 ± 0.099 and 5.57 ± 0.099 for the night-time and the control regimens, respectively. Back transforming the adjusted means to the original ppb scale resulted in 287 for the night-time regimen and 262 for the control regimen. Treatment efficacy results are presented in Figure 3.

Following use of the assigned products and comparing baseline pre-treatment to 24 hours, only the Pro-Health Night regimen provided a statistically significant (p<0.0001) reduction in the mean VSC level. There was no statistically significant change (p=0.695) in mean VSC relative to baseline with use of the control regimen. No evidence of a treatment carryover effect (p=0.345) was detected in the 24-hour VSC measurements. A statistically significant (p<0.0001) positive association was observed between the malodor measurements at baseline and 24-hours post-brushing.



*Statistically significant difference between treatments (p<0.0001)
**Original ppb scale back transformed from the natural log adjusted VSC means

Figure 3. Breath odor results (Total Volatile Sulfur Compounds).

In comparing the two treatment regimens for natural log VSC, the 24 hour post-brushing adjusted means ± standard errors were 5.15 ± 0.079 for the night-time regimen and 5.58 ± 0.079 for the control regimen, with treatments differing significantly (p<0.0001). Back transforming the adjusted means into the original ppb scale resulted in 172 for the night-time regimen relative to 265 for the control regimen, representing a 35% reduction in overnight breath malodor for the night-time regimen.

All regimens were well-tolerated, and there were no reports of adverse events in the clinical study.

Discussion

This clinical trial was undertaken to determine the impact on overnight breath malodor reduction of a night regimen consisting of a therapeutic dentifrice containing stannous fluoride, antibacterial mouth rinse containing CPC, and an oscillating-rotating power toothbrush when compared to use of a regular dentifrice and basic manual toothbrush. Stannous fluoride is an antibacterial agent shown to be effective against a wide range of microorganisms.[19] Sustained antimicrobial activity of stannous fluoride and its retention in dental plaque have been previously reported.[20,21] CPC is a cationic agent, a class which has been shown to be substantive to oral tissues.[22,23]

Post-treatment overnight ("morning breath") malodor was quantified in VSC levels using a portable sulfide monitor – Halimeter. Potentially confounding variables were controlled and a standard in breath odor evaluation was utilized. The Halimeter is an objective quantifier of volatile sulfides, and has been shown to be closely correlated with other more indirect or subjective breath measurements such as organoleptic diagnosis and tongue coating measurements[24,25] and even subject questionnaire self-evaluations.[26] Its suitability for breath odor clinical trials is well-established in the dental literature.[5,27,28]

In this clinical study, brushing and rinsing with the Crest Pro-Health Night paste-rinse/Oral-B Vitality power brush regimen twice during a 24-hour treatment period resulted in highly significant overnight breath odor reductions, 35% greater (p<0.0001) than those seen with use of the control Crest Cavity Protection/manual brush regimen. In fact, there was no change in adjusted mean VSC compared to pre-treatment after brushing with the control regimen for one day.

The findings of the study are consistent with the published literature, where breath benefits have frequently been reported with use of the active ingredients in the Pro-Health dentifrices and rinses: stannous fluoride and CPC alone or in combination. In a 5-day investigation by Gerlach and colleagues[29] for example, use of a 0.454% stannous fluoride dentifrice produced greater breath improvements when compared to sodium fluoride/pyrophosphate and sodium fluoride/triclosan dentifrice controls. A stabilized combination 0.454% stannous fluoride/sodium hexametaphosphate dentifrice has repeatedly been shown to be significantly more effective than either triclosan/copolymer or sodium fluoride controls in reducing malodor in both short-term[5,30,31] and longer-term[32] trials. A recent study demonstrated an overnight breath benefit of Crest Pro-Health dentifrice after one day of product use measured both instrumentally via Halimeter and by human nose via organoleptic assessments.[5] Another clinical study showed subjects rinsing with a 0.07% CPC mouthrinse (Crest Pro-Health) following brushing realized significantly greater VSC reductions than those rinsing with water alone at both overnight and daytime time points.[33]

The advanced technology found in the regimen toothbrush contributes to documented plaque removal effectiveness, which in turn can improve breath odor. The Oral-B Vitality Precision Clean rotating-oscillating power toothbrush was partnered with the Crest Pro-Health Night paste and rinse in the study. In a single-use clinical trial, it demonstrated up to 77% superior whole mouth plaque removal compared to a manual brush.[34] This is consistent with the findings of the Cochrane Report, which concluded powered toothbrushes with a rotating-oscillating design removed more plaque than manual brushes across 42 clinical trials.[35]

Integrating both the antimicrobial brush/rinse duo and the advanced-design toothbrushes into a single malodor-fighting regimen augmented the VSC reductions when compared to brushing only, likely due to the additive effects on bacteria reduction. While the individual products used in these trials all have demonstrated independent plaque and/or malodor reduction benefits, integrating them into a single regimen yields a 3-pronged attack on the microorganisms that lead to breath odor. Rather than suggesting a stand-alone product, dental professionals may want to consider recommending a combination regimen to their affected patients similar to that used in these trials to enhance adjunctive malodor reduction benefits. Additional research may be indicated to evaluate long-term effects of therapeutic regimens on oral malodor.

Conclusion

One-day use of a night-time antibacterial paste and rinse/advanced-design brush combination regimen provided a 35% reduction in overnight breath malodor compared to regular brushing.

Clinical Significance

Combining a proven therapeutic dentifrice, mouthrinse, and advanced design toothbrush in a single regimen is an efficient means of maximizing breath odor reductions.

References

1. Hirsh AR. The effect of odor and breath odor on social acceptance. J Breath Res. 2008; Feb 7;(2):1-4.
2. Lenton P, Magerus G, Bakdash B. Counseling and treating bad breath patients: A step-by-step approach. J Contemp Dent Pract. 2001; May;(2)2:046-061.
3. Sanz M, Roldán S, Herrera D. Fundamentals of breath malodor. J Contemp Dent Pract. 2001; Nov;(2)4:001-017.
4. Lee SS, Zhang W, Li Y. Halitosis update: A review of causes, diagnoses and treatments. J Calif Dent Assoc. 2007; Apr;(35)4:1-8.
5. Farrell S, Barker ML, Gerlach RW. Overnight malodor effect with a 0.454% stabilized stannous fluoride sodium hexametaphosphate dentifrice. Compen Contin Educ Dent. 2007; Dec;28(12)658-61; quiz662, 671.
6. DeBoever EH, Loesche, WJ. Assessing the contribution of anaerobic microflora of the tongue to oral malodor. J Am Dent Assoc. 1995; 126:1384-1393.
7. ADA Council on Scientific Affairs. Oral malodor. J Am Dent Assoc. 2003; Feb;134(2):209-14.
8. Suarez F, Furne J, Springfield J, Levitt MD. Morning breath odor: Influence of treatments on sulfur gases. J Dent Res. 2000; 79:1773-1777.
9. Rosenberg M, Kovzlovsky A, Gelernter I, Cherniak O, Gabbay J, Baht R, Eli I. Self-estimation of oral malodor. J Dent Res. 1995; Sept;74(9):1577-1582.
10. Rosenberg M. The science of bad breath. Sci Am. 2002; 286(4):72-79.
11. van den Broek AMWT, Feenstra L, de Baat C. A review of the current literature on aetiology and mesaurement methods of halitosis. J Dent. 2007; 35:627-35.
12. Rosenberg M, Kulkarni GV, Bosy A, McCulloch CAG. Reproducibility and sensitivity of oral malodor mesurements with a portable sulfide monitor. J Dent Res. 1991; 70:1436-40.
13. Ueno M, Shinada K, Yanagisawa T, Mori C, Yokoyama S, Furukawa S, Takehara S, Kawaguchi Y. Clinical oral malodor measurement with a portable sulfide monitor. Oral Diseases. 2008; 14:264-9.
14. Kleinberg I, Codipilly D. H2S generation and Eh reduction in cysteine challenge testing as a means of determining the potential of test products and treatments for inhibiting oral malodor. J Breath Res. 2008; 2; doi:10.1088/1752-7155/2/1/017-18.

15. De Boever EH, De Uzeda M, Loesche WJ. Relationship between volatile sulfur compounds, BANA-hydrolyzing bacteria and gingival health in patients with and without complaints of oral malodor. J Clin Dent. 1994; 4:114-9.
16. Greenstein RB-N, Goldberg S, Marku-Cohen S, Sterer N, Rosenberg M. Reduction of oral malodor by oxidyzing losenges. J Periodontol. 1997; 68:1176-81.
17. Oho T, Yoshida Y, Shimazaki Y, Yamashita Y, Koga T. Characteristics of patients complaining of halitosis and the usefulness of chromatography for diagnosing halitosis. Oral Surg, Oral Med, Oral Pathol, Oral Radiol. and Endodont. 2001; 91:531-4.
18. Furne J, Majerus G, Lenton P, Springfield J, Levitt DG, Levitt MD. Comparison of volatile sulfur compound concentrations measured with a sulfide detector vs. gas chromatography. J Dent Res. 2002; 81:140-3.
19. Tinanoff N. Review of the Antimicrobial Action of Stannous Fluoride. J Clin Dent. 1990; 2(1):22-27.
20. Scott D, Coggan J, Cruze C, Johnson R, Baker R, He T. retention of stannous ion in dental plaque: Pharmacokinetic modeling. J Dent Res. 2007; 86(Spec Iss). Abstract 1874.
21. Ramji N, Baig A, He T, Lawless MA, Saletta L, Suszcynsky-Meister E, Coggan J. Sustained Antibacterial Actions of a new Stabilized stannous fluoride dentifrice containing sodium hexametaphosphate. Compend Contin Educ Dent. 2005; 26(9):19-28.
22. Rolla G, Loe H, Schiott CR. The affinity of chlorhexidine for hydroxyapatite and salivary mucins. J Perio Res. 1970; 5:90-5.
23. Roberts WR, Addy M. Comparison of in vitro and in vivo antibacterial properties of anticeptic mouthrinses containing chlorhexidine, alexidine, CPC and hexetidine. Relevance to mode of action. J Clin Periodontol. 1981; 8:295-310.
24. Winkel EG, Tangerman A. Clinical association of volatile sulfur compounds, Halimeter values, organoleptic score and tongue coating in oral malodor. Oral Dis. 2005; Mar;11(Supplement 1): 99-99(1).
25. Li Y, Stephens J, Lee S., Wilson A, Zhang, W. Correlation and Consistency in Evaluating Oral Odor. J Dent Res. 2004; 82(Spec Iss A) Abstract 327.
26. Iwanicka-Grzegorek E; Michalik J; Kepa J; Wierzbicka M; Aleksinski M; Pierzynowska E. Subjective patients' opinion and evaluation of halitosis using Halimeter and organoleptic scores. Oral Dis. 2005; (11)Suppl 1[Abstract]:86-8.
27. Rosenberg M, Septon I, Eli I, Barr-Ness R, Gelernter I, Brenner S, Gabbay J. Halitosis measurement by an industrial sulfide monitor. J Periodontol 1991; 62:487–9.
28. Farrell S, Baker RA, Somogyi-Mann J, Witt JJ, Gerlach RW. Oral malodor reduction by a combination of chemotherapeutical and mechanical treatments. Clin Oral Investig. 2006; Jun;10(2):157-63.
29. Gerlach RW, Hyde JD, Poore CL, Stevens DP, Witt JJ. Breath effects of three marketed dentifrices: a comparative study evaluating single and cumulative use. J Clin Dent. 1998; 9(4):83-8.
30. Ford S, Bowman L, Fiedler S, Le Crone J, Ramsey L. Winston JL. Comparison of short-term breath efficacy of stannous fluoride and triclosan/copolymer dentifrice. J Dent Res. 2007; 86(Spec Iss). Abstract 2042.
31. Goulbourne EA Jr., Fiedler SK, He T, Baker RA, Winston JL. Short-term breath efficacy of stannous fluoride dentifrice. J Dent Res. 2007; 86(Spec Iss). Abstract 2038.
32. Winston JL, Fiedler SK, He T, Baker RA. Long-term breath efficacy of stannous fluoride dentifrice. J Dent Res. 2007; 86(Spec Iss). Abstract 0125.
33. Hamilton A, Gibb R, Witt J. Breath protection efficacy of a commercial CPC mouthrinse. J Dent Res. 2006; 85: Abstract 2051.
34. Goyal CR, Sharma N, Qaqish J, Cugini M, Thompson MC, Warren PR. Comparison of two power toothbrushes versus manual toothbrushing. J Dent Res. 2006; 85: Abstract 2043.
35. Robinson PG, Deacon SA, Deery C, Heanue M, Walmsley AD, Worthington HV, Glenny AM, Shaw WC. Manual versus powered toothbrushing for oral health. Cochrane Database Syst Rev. 2005; Apr 18;(2):CD002281. Review.

About the Authors

Svetlana Farrell, DDS, PhD

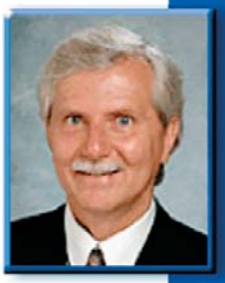
Dr. Svetlana Farrell is a Senior Clinical Scientist in Procter & Gamble's Oral Care Clinical department. She is responsible for leading worldwide clinical trials, including research on tooth whitening products, denture adhesives, dentifrice, and toothbrushes. Dr. Farrell received her dental degree from Novosibirsk Medical Institute in Novosibirsk, Russia and her PhD in Bioanalytical Chemistry from the University of Cincinnati. She has over 40 papers and presentations in her portfolio.

e-mail: farrell.s.2@pg.com

Matthew L. Barker, PhD

After receiving his PhD in Statistics from the University of Kentucky, Dr. Barker joined the Procter & Gamble Company as a Statistician supporting the Global Oral Care Clinical department located in Mason, OH, USA. Dr. Barker is currently a Senior Statistician responsible for designing, sizing, analyzing, and reporting results, and he has performed these duties for over 100 clinical studies evaluating the safety and efficacy of oral care products. Dr. Barker has published his research extensively including more than 100 peer-reviewed publications (manuscripts and abstracts).

Robert W. Gerlach, DDS, MPH



Dr. Gerlach is Research Fellow in Worldwide Clinical Investigations at Procter & Gamble. His clinical trials research includes initiatives in the areas of caries prevention, periodontal therapy, and esthetic dentistry, especially tooth whitening. With over 100 studies, his research has led to novel delivery systems for vital bleaching as well as new dentifrice formulations. Dr. Gerlach is a public health dentist who received a dental degree from the University of Michigan and a public health degree from the University of South Florida. His work experience includes various government and academic appointments as well as extensive private practice experience.

Amy Walanski, BS

Ms. Walanski is a Clinical Trial Manager in Worldwide Clinical Investigations at Procter & Gamble. Prior to this assignment, she was a Senior Researcher in Corporate Biotech where she conducted anti-inflammatory assay development. She graduated from Purdue University with a major in Biology. She is a member of the International Association for Dental Research.

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