

A Four-Week Clinical Study to Evaluate and Compare the Effectiveness of a Baking Soda Dentifrice and an Antimicrobial Dentifrice in Reducing Plaque

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Abstract

- **Objective:** To evaluate and compare the effectiveness in reducing plaque of a fluoride dentifrice containing baking soda and a non-baking soda fluoride dentifrice containing an antimicrobial (triclosan/copolymer) system after a single brushing and over a four-week period of daily brushing.
- **Methods:** A total of 207 subjects completed this randomized, blinded, parallel-group clinical study. Twenty-four hour plaque build-up was scored at baseline and after two and four weeks of twice-daily use of the products. Additionally, controlled single brushing with the assigned dentifrice, followed by post-brushing plaque assessment, was performed at the start (baseline visit) and end (Week-4 visit) of the study. Plaque was scored using the Turesky, *et al.* modification of Quigley-Hein Index at six sites per tooth, according to Soparkar's modification.
- **Results:** Mean baseline whole mouth plaque scores for the baking soda and triclosan dentifrice groups were 2.90 ± 0.40 and 2.90 ± 0.39 , respectively, and the difference was not statistically significant. Within-group analysis showed that both products significantly reduced the amount of plaque over the four-week period ($p < 0.001$). Between-group analysis showed that brushing with the baking soda dentifrice exhibited significantly greater reduction in plaque scores ($p < 0.001$) after two and four weeks of brushing as compared to the triclosan dentifrice. After four weeks, the mean plaque reduction for the baking soda dentifrice group (0.34 ± 0.32) was 2.22-fold greater than that observed for the triclosan dentifrice group (0.15 ± 0.24). Similarly, single brushing with the baking soda dentifrice showed a 1.88- to 2.08-fold greater pre- to post-brushing plaque difference as compared to the triclosan dentifrice at the baseline visit (mean plaque reduction: baking soda 0.54 ± 0.26 ; triclosan 0.28 ± 0.18 ; ratio 1.88 \times) and Week-4 visit (baking soda 0.47 ± 0.21 ; triclosan 0.23 ± 0.15 ; ratio 2.08 \times). Similar to the whole mouth scores, evaluation of various tooth sites (facial, lingual, proximal, and gingival) showed a significantly greater reduction in plaque scores for brushing with the baking soda dentifrice as compared to brushing with the triclosan dentifrice.
- **Conclusion:** The results of this study indicate that the baking soda dentifrice was more effective than the non-baking soda, antimicrobial dentifrice in plaque removal after a single tooth brushing, and in maintaining significantly lower plaque levels during a four-week period of twice daily, unsupervised tooth brushing.

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Introduction

Based on several studies comparing the effect of tooth brushing with and without conventional dentifrices, it seems likely that, in general, most dentifrices do not materially increase the direct removal of plaque biofilm by the toothbrush.¹⁻⁸ Dentifrices are used, however, to enhance the tooth brushing experience and to encourage regular oral hygiene and longer brushing times. Because plaque biofilm may eventually lead to caries and gingivitis, the tooth brushing process, as well as the dentifrice used, must be effective in order to reduce plaque accumulation and maintain oral health. A critically important ingredient in virtually all dentifrices is fluoride, which provides effective prevention against the development of dental caries.⁹ Furthermore, the abrasives in dentifrices tend to inhibit stain build-up on teeth and enhance tooth whiteness.¹⁰ Many dentifrices also contain additional ingredients for specific actions, for example pyrophosphates to inhibit tartar build-up and prevent stains.¹¹⁻¹³ Various antiplaque dentifrices, based on antimicrobials, have been introduced into the market. While the extended use of these

dentifrices can reduce plaque levels on teeth by inhibiting plaque growth, antimicrobials have no effect on the physical removal of plaque.

Despite its remarkably low abrasivity, baking soda, as an ingredient in some dentifrices, has been shown to have a significant beneficial effect in the removal of plaque biofilm.¹⁴⁻¹⁶ A series of studies has recently demonstrated that single brushings with dentifrices containing baking soda were more effective in removing plaque than brushing with certain dentifrices containing antimicrobials.^{17,18} Baking soda's mechanism of action is not yet understood. However, since the advantages of brushing with a baking soda dentifrice can be detected after a single brushing, it is likely that baking soda acts in some way to make the toothbrush more effective. This may possibly occur by improving the mechanical disruption of plaque biofilm by toothbrush bristles, which is enhanced by baking soda as the bristles penetrate into the plaque biofilm. On the other hand, since antimicrobials do presumably operate by inhibiting bacterial plaque growth, it might be expected that it would take a number of brushings with

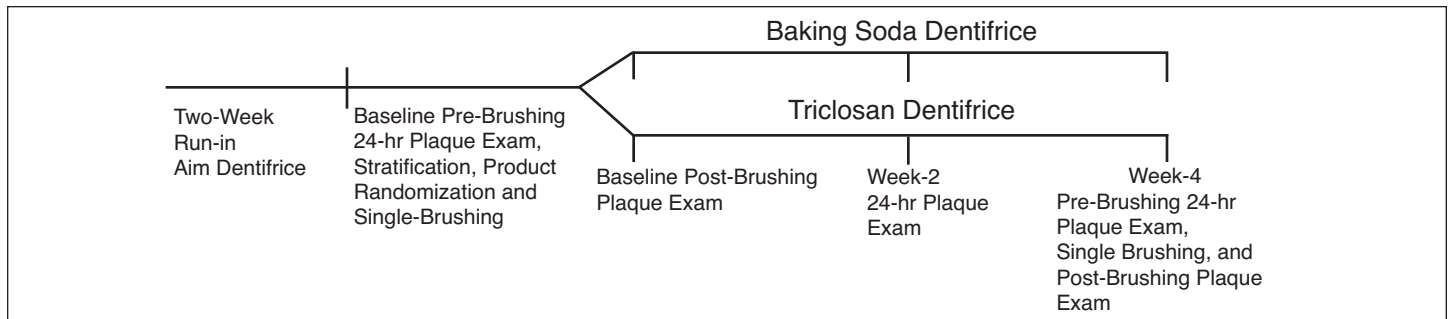


Figure 1. Clinical study design: Twice-daily brushing for four weeks and single brushings at baseline and Week-4 visits.

an antimicrobial dentifrice before the cumulative effect of bacterial growth inhibition can produce a net reduction in plaque.

The purpose of this clinical study was to evaluate and compare the effectiveness in reducing plaque of a fluoride dentifrice containing baking soda and a non-baking soda fluoride dentifrice containing an antimicrobial system (triclosan/copolymer) after a single brushing and over a four-week period of daily brushing.

Materials and Methods

Study Design

This four-week clinical study was a randomized, single-site, blinded, parallel-group comparison design. The study flow is presented in Figure 1. The study consisted of two experiments following a two-week acclimation period: 1) unsupervised, twice-daily brushing (60 seconds per brushing) for four weeks at home; and 2) supervised single brushing (60 seconds) at the study site during baseline and Week-4 visits. The design of this study allowed a comparison of plaque levels at baseline, interim, and final exams prior to study subjects performing their morning brushing. By comparing the pre- and post-brushing scores at the beginning (baseline visit) and completion (Week-4 visit) of the study, the study also allowed changes in efficiency of plaque removal due to one-month's regular use of the products to be compared.

Subject Population

The study protocol was initially reviewed and approved by an independent Institutional Review Board (IRB). Study participation was on a voluntary basis following written informed consent. Potential subjects completed a medical questionnaire and were then examined. To be enrolled in the study, subjects had to be 18 years of age or older, be in good health, and demonstrate adequate oral hygiene. They had to exhibit at least 20 natural teeth with both facial and lingual scoreable surfaces, which were in a good state of repair. Grossly carious, fully crowned, orthodontically banded abutment teeth and third molars were excluded from this count. The whole mouth plaque score had to be ≥ 2 based on the Turesky modification of the Quigley-Hein Plaque Index^{19,20} at the baseline exam, which followed a two-week acclimation period.

Prospective subjects were excluded from the study for the following reasons: Physical limitations affecting the ability of subjects to brush; presence of orthodontic bands, bridges, extensive crowns, or the presence of removable dentures; high levels of extrinsic stain or calculus deposits; soft tissue pathology;

moderate or severe recession; periodontitis affecting more than two teeth; dental hygiene neglect; use of medications, such as antibiotics, two weeks prior to or during the study, or with various medical conditions or diseases which might affect the study outcome; and inability to comply with study protocol. Candidates who had been enrolled in single brushing plaque studies during the past year were not eligible for participation.

Plaque Scoring Procedure

Whole mouth plaque assessments were made by the same examiner throughout the study. Subjects rinsed with an erythrosine-containing, plaque disclosing solution (G.U.M.[®] Dental Disclosing Solution—Red Cote, Sunstar Americas, Chicago, IL, USA), followed by a brief rinse with water to remove excess solution. Plaque levels were then assessed using the Turesky modification of the Quigley-Hein Plaque Index (Figure 2) on the facial and lingual surfaces of all teeth, except for the third molars,^{19,20} at six sites per tooth according to Soparkar's modification as described by Lobene, *et al.*²¹ Thus for scoring purposes, each tooth was divided into six areas: mesio-facial, mid-facial, disto-facial, mesio-lingual, mid-lingual, and disto-lingual. The scores from all sites were summed and divided by the total number of sites. The subject-wise mean plaque score was obtained by adding the indices for the teeth and dividing by the number of teeth examined.

Score	Description
0	No visible plaque.
1	Separate flecks of plaque at the cervical margin of the tooth.
2	A thin, continuous band of plaque (up to 1 mm wide) at the cervical margin.
3	A band of plaque wider than 1 mm but covering less than one-third of crown.
4	Plaque covering at least one-third but less than two-thirds of crown.
5	Plaque covering two-thirds or more of crown.

Figure 2. Turesky et al. modification of the Quigley-Hein Index.

Clinical Procedures and Test Products

Before the test phase, subjects were recruited for the study and provided with a regular dentifrice (Aim[®] Cavity Protection Gel, Church & Dwight Co., Inc., Princeton, NJ, USA) and a manual toothbrush (Oral-B[®] 35 Compact Soft Toothbrush, Procter & Gamble, Cincinnati, OH, USA) to use during a two-week acclimation period to reduce the "novelty" (Hawthorne) effect of being in the study. Subjects agreed to refrain from the use of interdental cleaning aids, chewing gums, or mouth rinses, and not

to have their teeth cleaned by a dentist or hygienist during the study. Prior to the baseline examination, subjects refrained from brushing for 24 hours, and did not eat, drink, or smoke prior to the examination.

At the baseline visit, subjects exhibiting a whole mouth plaque score of ≥ 2 (Baseline Pre-Brushing Plaque Score) proceeded into the test phase. Subjects were stratified based upon age, gender, and baseline plaque level, and randomly assigned to either a baking soda dentifrice (Arm & Hammer® Advance White® Brilliant Sparkle, Church & Dwight Co., Inc., Princeton, NJ, USA) or a baking soda-free antimicrobial (containing 0.3% triclosan/2.0% copolymer) dentifrice (Colgate® Total® Clean Mint Dentifrice, Colgate-Palmolive Company, New York, NY, USA). The toothbrush (Oral-B 35 Compact Soft) was the same for all subjects throughout the study. The subjects brushed with a weighed quantity (1.5 g) of their assigned dentifrice for 60 seconds at the study site under supervision, followed by a baseline post-brushing plaque exam. For the four-week test phase, subjects were given a timer and instructed to apply a full ribbon of their assigned dentifrice on the toothbrush provided and brush twice daily (60 seconds per brushing) at home.

After two weeks of daily brushing at home, subjects returned for an interim examination without having brushed for 24 hours. After an oral soft tissue examination, plaque was disclosed and the examiner performed a plaque assessment. No single brushing at the study site was performed at the two-week visit. Subjects returned home for the final two weeks of twice-daily unsupervised brushing with their assigned dentifrice.

After a total of four weeks, subjects returned for the final examination without having brushed for 24 hours. After performing an oral soft tissue examination, plaque was disclosed and the examiner performed a pre-brushing plaque assessment (Week-4 Plaque Score). Immediately following the pre-brushing examination, subjects brushed their teeth for 60 seconds with a weighed quantity (1.5 g) of their assigned dentifrice under supervision, followed by a final post-brushing plaque assessment (Week-4 Post-Brushing Plaque Score).

Data Analysis

The primary efficacy variable for this study was changes in plaque score. All group data are presented as Mean \pm Standard Deviation (SD). For single brushing, plaque reduction was determined by calculating the pre- minus post-brushing difference. For daily brushing, plaque reduction was determined by the difference between 24-hour plaque scores at Week-2 versus baseline, and Week-4 versus baseline. Data analysis consisted of within-group (longitudinal) and between-group comparisons of change from baseline in plaque scores at each exam time point. For each product, the within-group analysis compared baseline mean scores and post-brushing mean scores using Student's t-test for paired data. The between-group comparison at each exam time point utilized a post-ANCOVA t-test with baseline (24-hour, pre-brushing) plaque scores as a covariate, and used two-sided tests at a 0.05 level of significance.

Results

A total of 218 subjects were enrolled in the study, and 207 subjects completed the study (Table I). No subject discontinued

Table I
Demographics

	N	Gender		Age	
		Female	Male	Mean \pm SD	Range
Baking Soda Dentifrice	105	70	35	39.5 \pm 1.3	18–69
Triclosan Dentifrice	102	74	28	39.4 \pm 1.3	18–71

participation due to adverse effects. Of 207 subjects completing the study, there were 144 females and 63 males, ranging in age from 18 to 71 years (overall mean age was 39 years). A total of 105 subjects used the baking soda dentifrice, and 102 subjects used the triclosan dentifrice.

Comparison of Mean Plaque Scores After Two and Four Weeks of Daily Brushing at Home

Tables II and III provide summaries of the within-group (versus baseline) and between-group comparisons of the mean 24-hour plaque index scores after brushing with the assigned dentifrice for two and four weeks, respectively.

The baseline mean whole mouth plaque scores were 2.90 ± 0.40 for the baking soda dentifrice group, and 2.90 ± 0.39 for the triclosan dentifrice group, and were not statistically significantly different ($p > 0.05$). Within-group analysis showed that both products demonstrated highly statistically significant reductions in mean whole mouth plaque scores after two and four weeks of daily brushing versus baseline ($p < 0.001$). Between-group analysis showed that after two weeks of use, the group brushing with the baking soda dentifrice had a plaque reduction of 0.40 ± 0.30 versus baseline, which was significantly ($p < 0.001$) greater than the reduction of 0.22 ± 0.25 obtained by the group using the triclosan dentifrice. After four weeks, the group brushing with the baking soda dentifrice had a significantly ($p < 0.001$) greater plaque reduction score (0.34 ± 0.32) than the group brushing with the triclosan dentifrice (0.15 ± 0.24). Comparison of the mean plaque reduction scores showed that after two weeks and four weeks of brushing, the baking soda dentifrice group was associated with 1.85-fold (85%) and 2.22-fold (122%) greater reductions in plaque scores, respectively, than the triclosan dentifrice group (Tables II and III).

Analyses of plaque scores for facial, lingual, proximal and gingival sites produced similar results to those of whole mouth plaque scores in that the baking soda group produced a statistically significantly greater reduction in mean plaque scores than the triclosan dentifrice (Tables II and III). Baseline mean plaque scores for the facial, lingual, proximal, and gingival sites were well balanced across the two product groups and were not statistically significantly different ($p > 0.05$). Although both product groups showed reductions in mean plaque scores for all tooth sites after two and four weeks of daily brushing versus baseline, the baking soda dentifrice group consistently showed significantly greater plaque reduction scores than the triclosan dentifrice group by 1.7- to 2.1-fold after two weeks of brushing, and 2.0- to 2.5-fold after four weeks of brushing (Tables II and III).

Comparisons of Mean Plaque Scores after Supervised Single Brushing at the Baseline Visit and Final Week-4 Visit

Figure 3 presents whole mouth plaque reduction efficiency of single brushing with the baking soda dentifrice and triclosan dentifrice

Table II
Two-Week Daily Brushing Plaque Results

Parameter	Product Group	N	Within-Group Analysis			Between-Group Comparisons	
			Baseline Plaque Score*	Reduction from Baseline*	p	Greater Plaque Reduction Score (Ratio; %)*	p
Whole Mouth	Baking Soda	105	2.90 ± 0.40	0.40 ± 0.30	< 0.001	1.85×; 85%	< 0.001
	Triclosan	102	2.90 ± 0.39	0.22 ± 0.25	< 0.001		
Facial	Baking Soda	105	2.83 ± 0.57	0.53 ± 0.48	< 0.001	1.76×; 76%	< 0.001
	Triclosan	102	2.82 ± 0.57	0.30 ± 0.42	< 0.001		
Lingual	Baking Soda	105	2.96 ± 0.38	0.27 ± 0.21	< 0.001	2.05×; 105%	< 0.001
	Triclosan	102	2.98 ± 0.34	0.13 ± 0.20	< 0.001		
Proximal	Baking Soda	105	3.12 ± 0.35	0.35 ± 0.27	< 0.001	1.72×; 72%	< 0.001
	Triclosan	102	3.12 ± 0.33	0.20 ± 0.22	< 0.001		
Gingival	Baking Soda	105	2.45 ± 0.54	0.50 ± 0.42	< 0.001	2.06×; 106%	< 0.001
	Triclosan	102	2.45 ± 0.55	0.24 ± 0.36	< 0.001		

* Mean ± SD.

* Difference in plaque reduction mean scores between dentifrices is expressed as a ratio and percentage of plaque reduction score for the triclosan dentifrice. A positive value indicates greater plaque reduction in favor of brushing with baking soda dentifrice as compared to triclosan dentifrice. Ratio = (baking soda mean plaque reduction) / (triclosan mean plaque reduction); % difference in plaque reduction = 100% × (baking soda mean plaque reduction – triclosan mean plaque reduction) / triclosan mean plaque reduction.

Table III
Four-Week Daily Brushing Plaque Results

Parameter	Product Group	N	Within-Group Analysis			Between-Group Comparisons	
			Baseline Plaque Score*	Reduction from Baseline*	p	Greater Plaque Reduction Score (Ratio; %)*	p
Whole Mouth	Baking Soda	105	2.90 ± 0.40	0.34 ± 0.32	< 0.001	2.22×; 122%	< 0.001
	Triclosan	102	2.90 ± 0.39	0.15 ± 0.24	< 0.001		
Facial	Baking Soda	105	2.83 ± 0.57	0.46 ± 0.51	< 0.001	2.33×; 133%	< 0.001
	Triclosan	102	2.82 ± 0.57	0.20 ± 0.39	< 0.001		
Lingual	Baking Soda	105	2.96 ± 0.38	0.23 ± 0.22	< 0.001	2.03×; 103%	< 0.001
	Triclosan	102	2.98 ± 0.34	0.11 ± 0.19	< 0.001		
Proximal	Baking Soda	105	3.12 ± 0.35	0.31 ± 0.27	< 0.001	2.07×; 107%	< 0.001
	Triclosan	102	3.12 ± 0.33	0.15 ± 0.21	< 0.001		
Gingival	Baking Soda	105	2.45 ± 0.54	0.40 ± 0.45	< 0.001	2.50×; 150%	< 0.001
	Triclosan	102	2.45 ± 0.55	0.16 ± 0.35	< 0.001		

* Mean ± SD.

* Difference in plaque reduction mean scores between dentifrices is expressed as a ratio and percentage of plaque reduction score for the triclosan dentifrice. A positive value indicates greater plaque reduction in favor of brushing with baking soda dentifrice as compared to triclosan dentifrice. Ratio = (baking soda mean plaque reduction) / (triclosan mean plaque reduction); % difference in plaque reduction = 100% × (baking soda mean plaque reduction – triclosan mean plaque reduction) / triclosan mean plaque reduction.

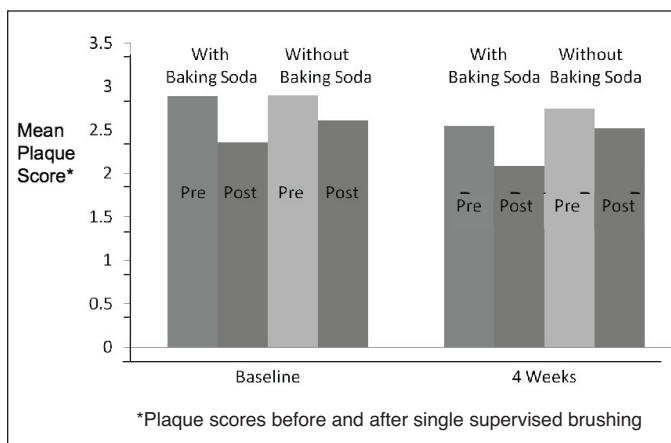


Figure 3. Plaque removal efficiency at start (Baseline visit) and end (Week-4 visit) of study.

under supervision at the start (baseline visit) and at the end (Week-4 visit) of the study. Tables IV and V provide summaries of the baseline visit and Week-4 visit plaque results, respectively, for whole mouth as well as facial, lingual, proximal, and gingival sites.

As indicated earlier, the baseline pre-brushing plaque scores for the two product groups were well balanced and not statistically significantly different ($p > 0.05$) for whole mouth as well as facial, lingual, proximal, and gingival sites (Table IV). Within-group analysis for the baseline visit showed that single brushing with either the baking soda or triclosan dentifrice resulted in a statistically significant reduction in the whole mouth plaque score ($p < 0.001$). Between-group comparison analysis showed that the pre- to post-brushing plaque difference for the baking soda group (0.54 ± 0.26) was significantly greater ($p < 0.001$) than the pre- to post-brushing plaque difference for the triclosan dentifrice group (0.28 ± 0.18). This comparison of reduction in

Table IV
Baseline Visit—Single Brushing Plaque Results

Parameter	Product Group	N	Within-Group Analysis			Between-Group Comparisons	
			Baseline Plaque Score*	Reduction from Baseline*	Pre- to Post-Brushing Difference*	Greater Plaque Reduction Score (Ratio; %)*	p
Whole Mouth	Baking Soda	105	2.90 ± 0.40	2.36 ± 0.46	0.54 ± 0.26	1.88×; 88%	< 0.001
	Triclosan	102	2.90 ± 0.39	2.61 ± 0.40	0.28 ± 0.18		
Facial	Baking Soda	105	2.83 ± 0.57	2.00 ± 0.64	0.83 ± 0.45	1.86×; 86%	< 0.001
	Triclosan	102	2.82 ± 0.57	2.37 ± 0.55	0.45 ± 0.28		
Lingual	Baking Soda	105	2.96 ± 0.38	2.72 ± 0.46	0.24 ± 0.19	1.98×; 98%	< 0.001
	Triclosan	102	2.98 ± 0.34	2.86 ± 0.38	0.12 ± 0.16		
Proximal	Baking Soda	105	3.12 ± 0.35	2.68 ± 0.43	0.44 ± 0.24	2.16×; 116%	< 0.001
	Triclosan	102	3.12 ± 0.33	2.92 ± 0.34	0.20 ± 0.16		
Gingival	Baking Soda	105	2.45 ± 0.54	1.72 ± 0.58	0.73 ± 0.38	1.64×; 64%	< 0.001
	Triclosan	102	2.45 ± 0.55	2.00 ± 0.57	0.45 ± 0.26		

* Mean ± SD.

* Difference in plaque reduction mean scores between dentifrices is expressed as a ratio and percentage of plaque reduction score for the triclosan dentifrice. A positive value indicates greater plaque reduction in favor of brushing with baking soda dentifrice as compared to triclosan dentifrice. Ratio = (baking soda mean plaque reduction) / (triclosan mean plaque reduction); % difference in plaque reduction = 100% × (baking soda mean plaque reduction – triclosan mean plaque reduction)/triclosan mean plaque reduction.

Table V
Week-4 Final Visit - Single Brushing Plaque Results

Parameter	Product Group	N	Pre-Brushing Plaque Score*	Post-Brushing Plaque Score*	Pre- to Post-Brushing Difference*	Greater Plaque Reduction Score (Ratio; %)*	p
Whole Mouth	Baking Soda	105	2.55 ± 0.43	2.09 ± 0.45	0.47 ± 0.21	2.08×; 108%	< 0.001
	Triclosan	102	2.74 ± 0.40	2.52 ± 0.39	0.23 ± 0.15		
Facial	Baking Soda	105	2.37 ± 0.61	1.73 ± 0.61	0.65 ± 0.35	1.80×; 80%	< 0.001
	Triclosan	102	2.62 ± 0.58	2.26 ± 0.53	0.36 ± 0.27		
Lingual	Baking Soda	105	2.73 ± 0.37	2.44 ± 0.49	0.29 ± 0.19	3.17×; 217%	< 0.001
	Triclosan	102	2.87 ± 0.36	2.77 ± 0.38	0.09 ± 0.11		
Proximal	Baking Soda	105	2.80 ± 0.37	2.39 ± 0.44	0.42 ± 0.19	2.41×; 141%	< 0.001
	Triclosan	102	2.97 ± 0.33	2.80 ± 0.33	0.17 ± 0.14		
Gingival	Baking Soda	105	2.06 ± 0.60	1.48 ± 0.56	0.57 ± 0.33	1.73×; 73%	< 0.001
	Triclosan	102	2.29 ± 0.60	1.96 ± 0.56	0.33 ± 0.24		

* Mean ± SD.

* Difference in plaque reduction mean scores between dentifrices is expressed as a ratio and percentage of plaque reduction score for the triclosan dentifrice. A positive value indicates greater plaque reduction in favor of brushing with baking soda dentifrice as compared to triclosan dentifrice. Ratio = (baking soda mean plaque reduction) / (triclosan mean plaque reduction); % difference in plaque reduction = 100% × (baking soda mean plaque reduction – triclosan mean plaque reduction)/triclosan mean plaque reduction.

mean plaque scores for the two groups showed that single brushing with the baking soda dentifrice exhibited an 88% (ratio 1.88-fold) greater reduction in plaque scores than brushing with the triclosan dentifrice.

Within-group analysis for the final visit single brushing showed that both the baking soda and triclosan dentifrices resulted in statistically significant reductions in whole mouth plaque scores ($p < 0.001$). At the final visit, the mean 24-hour pre-brushing plaque score was lower for the baking soda dentifrice group than the triclosan dentifrice group (Table V). Brushing with the baking soda dentifrice resulted in a significantly greater pre- to post-brushing plaque difference (0.47 ± 0.21) than brushing with the triclosan dentifrice (0.23 ± 0.15), with a ratio of 2.08 (108%) greater reduction in plaque scores in favor of the baking soda dentifrice group.

Analyses of mean plaque scores for facial, lingual, proximal, and gingival sites for the baseline and final visits exhibited sim-

ilar results to those of whole mouth plaque scores, in that single brushing with the baking soda dentifrice exhibited a statistically significantly greater ($p < 0.001$) pre- to post-brushing plaque difference than a single brushing with the triclosan dentifrice at the start and end of the study (Tables IV and V).

Discussion

In theory, the ability to remove plaque from teeth by brushing is a function of the effectiveness of the toothbrush in displacing plaque, the ability of the dentifrice to enhance plaque removal due to an ingredient like baking soda, and the presence in the dentifrice of ingredients, like triclosan, which inhibit plaque growth. Clinical studies have shown a consistent plaque removal advantage for a single brushing with a baking soda dentifrice over a single brushing with dentifrices not containing this ingredient.¹⁶⁻¹⁸ Furthermore, in single brushing studies, baking soda dentifrices outperformed a dentifrice containing an antimicrobial agent which

inhibits plaque growth.^{17,18} On the other hand, a dentifrice containing triclosan has been consistently shown in long-term studies to reduce plaque scores by inhibiting plaque growth. However, the effect of brushing with a baking soda dentifrice under daily use conditions beyond a single brushing has not been evaluated. In this study, a dentifrice containing baking soda which enhances plaque removal was compared to a dentifrice containing triclosan, an antimicrobial which inhibits plaque growth. The relative effectiveness of two dentifrices in a longer-term study depends on whether the agent providing enhanced plaque removal can offset the plaque growth inhibitory effect of the antimicrobial.

The action of baking soda is unlikely to result from the mild antimicrobial properties of this ingredient, especially since its antimicrobial activity is slow acting and its residence time in the mouth is transient due to its solubility.²² Therefore, it is likely that baking soda might have some physical effect on plaque biofilm dispersion which contributes to the toothbrush removing it more effectively.

In a previous paper, we discussed three possible modes of action by which baking soda may enhance plaque removal by the toothbrush.¹⁶ First, the crystals of baking soda are relatively large compared to other abrasives which may help the toothbrush physically displace plaque from the tooth surface. Second, dissolved baking soda may reduce the viscosity of the polysaccharide matrix of the plaque fluid, making it easier to brush away by increasing the ability of bristles to penetrate and disperse biofilm. Third, dissolved bicarbonate ions from baking soda may tie up calcium ions, thereby reducing bonds not only between plaque bacteria, but also the tooth surface which are mediated by calcium ions.²³⁻²⁵ We also propose two additional mechanisms of action. Baking soda may promote the detergent action of the surfactant in a dentifrice due to its alkalinity. This would also favor better penetration and disruption of oral biofilm. Furthermore, bicarbonate ions may bind to sites on the tooth surface giving it a negative charge, resulting in displacement of bacteria or other ingredients in plaque from the tooth surface.

Based on the superior plaque removing properties of dentifrices containing baking soda in single brushing studies, it might be expected that such products would perform well against conventional dentifrices in repeated-use studies. However, it is interesting that a baking soda dentifrice would outperform a baking soda-free dentifrice containing a proven antimicrobial agent such as triclosan. Clinical studies of daily brushing following a prophylaxis with the triclosan dentifrice or placebo dentifrice over various time periods demonstrated consistent plaque inhibitory effect of the triclosan dentifrice, although the degree of inhibition varied widely from study to study.²⁶⁻³⁴ In this study, although the subjects did not undergo prophylaxis and therefore started with some level of existing dental plaque, the baking soda dentifrice significantly outperformed the triclosan dentifrice in reducing 24-hour mean plaque scores after two weeks and four weeks of use.

In conclusion, for evaluations involving controlled single tooth brushings and twice-daily home tooth brushing over four weeks, this study demonstrated that the baking soda dentifrice was significantly more effective in reducing and controlling plaque accumulation as compared to a clinically proven anti-

microbial dentifrice. It would be valuable in future studies to examine the relative plaque reduction effectiveness of brushing with a baking soda dentifrice over longer usage periods than four weeks, and its potential effectiveness in reduction of gingivitis.

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