

A comparison of toothpaste tablets and a sodium fluoride dentifrice for the control of supragingival plaque and gingivitis: A 2-week randomized controlled trial

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ABSTRACT: Purpose: To compare toothpaste tablets containing 0.243% sodium fluoride and a conventional sodium fluoride dentifrice for gingivitis and plaque control over a 2-week period. **Methods:** Forty adult participants were randomized into two groups: Toothpaste tablets (Colgate Anywhere Travel Toothpaste Tablets) and conventional dentifrice (Colgate Cavity Protection). A blinded examiner measured the gingival and plaque index at baseline and after 2 weeks. A questionnaire was distributed at the end to determine overall satisfaction of the product used. Statistical analyses were performed separately for the gingival index and plaque index scores. Comparisons of the two treatment groups with respect to baseline and 2-week gingival index and plaque index scores were performed using Mann-Whitney U-test. Within-treatment comparisons of the gingival index and plaque index scores obtained at the 2-week examinations versus baseline were performed using Wilcoxon test. **Results:** Both groups had statistically significant improvements in plaque control at the 2-week visit ($P < 0.05$). There was no statistically significant difference between groups for gingival and plaque index at the 2-week visit ($P > 0.05$). Overall satisfaction for both products were positive while perception on “texture/foaminess” was more negative for toothpaste tablets ($P = 0.001$). The results showed that toothpaste tablets’ short-term performance on gingivitis and plaque control was equivalent to conventional dentifrice while the “texture/foaminess” of toothpaste tablets was found to be less appealing. (*Am J Dent* 2023;36:172-176).

CLINICAL SIGNIFICANCE: Toothpaste tablets are a relatively new form of toothpaste that can be a viable alternative to conventional dentifrice with the added benefit of an eco-friendly way of maintaining oral hygiene.

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Introduction

Tooth brushing is a vital practice in more than 300 million Americans’ oral hygiene routines, and it is widely accepted that the control of plaque and gingivitis is the key to periodontal health. The American Dental Association (ADA) defines the maintenance of good oral hygiene as tooth brushing twice a day.¹ Regular brushing and flossing are important for removing biofilm from the teeth, because if left undisturbed biofilm quickly forms an organized matrix that contains a diverse oral microbiota, including periodonto-pathogenic and commensal organisms.² The inflammatory reaction of the host as a defense to those pathogens, coupled with bacterial virulence factors, can result in interaction between the tooth and the periodontium leading to periodontal disease.^{3,4}

Along with the toothbrush and floss, the use of a dentifrice facilitates removal of plaque and debris from teeth. It comes in gel, paste or powder form and generally contains mild abrasives, humectants, flavoring agents, thickening agents and detergent.⁵ In addition to fluoride that has anti-cavity properties,⁶ dentifrices may contain other ingredients that improve oral health such as reducing tooth sensitivity,^{7,8} preventing gingivitis,⁹ resisting enamel erosion,¹⁰ whitening teeth,¹¹ or improving bad breath.¹² In addition, natural dentifrice is made with organic or natural ingredients and is often free of harsh chemicals, making it a popular choice for individuals who prefer holistic options.¹³

The zero-waste movement has created a significant shift in consumers’ preference in oral hygiene care products leading to innovative developments that meet new needs and challenges.

Toothpaste tablets generally contain natural ingredients and are packaged in biodegradable or reusable containers. It is important to note that toothpaste tablet’s development was initially driven by the desire to improve fluoride bioavailability and remineralization, rather than its environmental benefits.¹⁴⁻¹⁶ However, the recent trend towards eco-friendly and sustainable oral hygiene products has certainly increased the popularity of toothpaste tablets.¹⁷ Although these low-waste tablets are garnering popularity, there is scarce information on the efficacy of toothpaste tablets on gingival health, plaque removal, caries prevention, and user-friendliness.¹⁷

Therefore, the objective of the study was to evaluate the control of supragingival plaque and gingivitis of two commercially available dentifrices: a dentifrice delivered as tablets containing 0.243% sodium fluoride (Colgate Anywhere Travel Toothpaste Tablets[®]) and a conventional dentifrice packaged in plastic tubes containing 0.243% sodium fluoride (Colgate Cavity Protection Toothpaste[®]). It was hypothesized that there would be no difference in gingival index and plaque index scores between the two dentifrices after 2 weeks usage. Also, it was hypothesized that there would be no difference in participants’ overall perception and satisfaction on the use of the products.

Materials and Methods

The Institutional Review Board approved the study (IRB # 5220342). This study employed a single-blind, randomized, two-treatment, parallel-group design. The study enrolled adult male and female participants from the Southern California,

USA area. The participants had to be 18 years or older, comply with the study protocol, read and understand the consent form, be available during the study period of 2 weeks requiring two visits, and possess more than 20 natural teeth. However, participants were excluded from the study if they were pregnant and/or nursing or under the age of 18.

Prospective participants reported to the clinical facility having refrained from any oral hygiene procedures in the morning and eating prior to the visit. Participants signed an Informed Consent form and were screened with respect to the inclusion/exclusion criteria. A single examiner performed all examinations, and the intraclass correlation coefficient was 0.875. Qualifying participants received a baseline gingivitis and supragingival plaque examination and were randomized into two treatment groups. The two dentifrices tested in this study were: (1) a commercially available dentifrice delivered as tablets containing 0.243% sodium fluoride (Colgate Anywhere Travel Toothpaste Tablets) and (2) a commercially available dentifrice containing 0.243% sodium fluoride (Colgate Cavity Protection Toothpaste).

The treatment consisted of the assigned dentifrice and a soft-bristled toothbrush (Colgate Slim Soft Gliding Tips Toothbrush,^a Extra Soft, Compact Head). The participants were instructed to brush their teeth twice daily for 2 minutes using only the assigned dentifrice and toothbrush. They were allowed to continue their routine oral hygiene procedures such as flossing and using inter-dental stimulators. There were no restrictions regarding diet or smoking during the study period, although the participants were instructed to refrain from oral hygiene procedures and eating on the day of the examination.

After 2 weeks of product use, the participants returned to the clinical facility for examinations of gingivitis and supra-gingival plaque by the same dental examiner that was blinded to the group allocation. Participants were also questioned about any adverse events that may have occurred and were asked to complete a 10-item questionnaire about their product usage experience.

Löe-Silness Gingival Index - Gingivitis was scored according to the Löe-Silness Gingival Index.¹⁸ Each tooth was divided into six surfaces, three facial and three lingual, as follows: (1) mesio-facial; (2) mid-facial; (3) disto-facial; (4) mesio-lingual; (5) mid-lingual; and (6) disto-lingual. Teeth included in the scoring were: #3, 7, 12, 19, 23, 28. Subject-wise scores were determined by averaging the values obtained over all scored surfaces.

The gingiva adjacent to each tooth surface was scored as follows:

- 0 = Absence of inflammation.
- 1 = Mild inflammation - slight change in color and little change in texture.
- 2 = Moderate inflammation - moderate glazing, redness, edema, and hypertrophy.
- 3 = Severe inflammation - marked redness and hypertrophy. Tendency for spontaneous bleeding.

Quigley-Hein Plaque Index - Plaque was scored according to the Turesky modification of the Quigley-Hein Plaque Index.^{19,20} Each tooth was divided into six surfaces, three facial and three lingual, as follows: (1) mesio-facial; (2) mid-facial; (3) disto-facial; (4) mesio-lingual; (5) mid-lingual; and (6) disto-lingual.

Teeth included in the scoring were: #3, 7, 12, 19, 23, 28. Subject-wise scores were determined by averaging the values obtained over all scored surfaces.

Plaque was visualized with a disclosing solution (2 Tone^b) and scored on each tooth surface as follows:

- 0 = No plaque.
- 1 = Separate flecks of plaque at the cervical margin.
- 2 = A thin, continuous band of plaque (up to 1 mm) at the cervical margin.
- 3 = A band of plaque wider than 1 mm but covering less than 1/3 of the side of the crown of the tooth.
- 4 = Plaque covering at least 1/3, but less than 2/3 of the side of the crown of the tooth.
- 5 = Plaque covering 2/3 or more of the side of the crown of the tooth.

Adverse events - Adverse events were determined by verbal indications from the participants or by visual examination by the dental examiner.

Product use perception - On completion of the 2-week gingivitis and supragingival plaque assessment, participants completed a 10-item questionnaire that included gender, age and compliance of product usage and perception on cleanliness after usage, texture/foaminess, flavor, ease of use, the importance of eco-friendliness of toothpaste products, intention to switch to tablets if the price was the same as conventional toothpaste, and overall satisfaction. The perception responses were on a 4-point Likert scale ranging from strongly agree (1) to strongly disagree (4).

Data analysis - Descriptive statistics were conducted to summarize all variables in the study. Statistical analyses were performed separately for the gingival index and plaque index scores. Comparisons of the two treatment groups with respect to baseline and 2-week gingival index and plaque index scores were performed using Mann-Whitney U-test. Within-treatment comparisons of the gingival index and plaque index scores obtained at the 2-week examinations versus baseline were performed using Wilcoxon test. Based on the power analysis, a sample size of 19 was needed in each group for 80% power with alpha = 0.05 and an effect size of 0.3 units. To account for a 5% attrition rate, a total of 20 participants were recruited in each group. Intention-to-treat analysis was performed for all parameters. Perception responses on the questionnaire were dichotomized into positive (strongly agree and agree) and negative responses (disagree and strongly disagree). Pearson's Chi-Squared test was used to evaluate difference in perception and satisfaction on the use of the two products. IBM SPSS Statistics^c version 24 was used for the data analysis at a significance level of 0.05.

Results

A total of 40 participants (Female: 26; Male: 14) complied with the protocol and completed the 2-week clinical study. The age ranged from 18 to 30, with a mean of 25 years. There was no statistically significant difference between the two groups with respect to gender distribution and age ($P > 0.05$, in both instances). Throughout the study, no adverse effects on the oral hard or soft tissues were reported by the participants when questioned.

Table 1. Summary of the Baseline Loe-Silness Gingival Index and Quigley-Hein Plaque Index scores.

Parameter	Dentifrice	N	Baseline (Mean±SD)	Mean difference	P-value	95% confidence interval	
						Lower	Upper
Gingivitis	Toothpaste tablets	20	1.35±0.26	-0.08	0.473	-0.19	0.13
	Conventional dentifrice	20	1.37±0.2				
Plaque	Toothpaste tablets	20	2.80±0.58	0.06	0.665	-0.36	0.38
	Conventional dentifrice	20	2.78±0.46				

Table 2. Summary of the 2-week Loe-Silness Gingival Index and Quigley-Hein Plaque Index scores.

Parameter	Dentifrice	N	2-week (Mean±SD)	Mean difference	P-value	95% confidence interval	
						Lower	Upper
Gingivitis	Toothpaste tablets	20	1.33±0.26	-0.06	0.370	-0.167	0.083
	Conventional dentifrice	20	1.34±0.18				
Plaque	Toothpaste tablets	20	2.59±0.49	0.08	0.579	-0.25	0.417
	Conventional dentifrice	20	2.56±0.48				

Table 3. Summary of within group analysis of Loe-Silness Gingival Index and Quigley-Hein Plaque Index scores.

Parameter	Dentifrice	N	2-week (Mean±SD)	Mean difference	P-value	95% confidence interval	
						Lower	Upper
Gingivitis	Toothpaste tablets	20	-0.026	1.9	0.765	-0.117	0.064
	Conventional dentifrice	20	-0.011	0.8	0.936	-0.070	0.048
Plaque	Toothpaste tablets	20	-0.224	8.0	0.017	-0.453	0.005
	Conventional dentifrice	20	-0.218	7.8	0.035	-0.391	-0.045

Table 4. Perception of the use of dentifrice by group (% positive/negative responses).

	Toothpaste tablets		Conventional dentifrice		P-value
	Positive	Negative	Positive	Negative	
My teeth felt clean after the use of the product	85	15	90	10	0.633
The texture/foaminess of the product was adequate	50	50	95	5	0.001
The flavor of the product was adequate	85	15	90	10	0.633
It was easy to use the product	85	15	100	0	0.072
The eco-friendliness of toothpaste products is important to me	95	5	90	10	0.548
If the cost of the product was the same as to my conventional toothpaste, I would use the product regularly	75	25	90	10	0.212
Overall, I was satisfied with using the product	80	20	95	5	0.151

Baseline data

Loe-Silness Gingival Index and Quigley-Hein Plaque Index - Table 1 summarizes the gingival and plaque index scores measured at baseline for participants who completed the study. The mean baseline gingival index scores were 1.37 for the toothpaste tablets group and 1.34 for the conventional dentifrice group. The mean baseline plaque index scores were 2.78 for the toothpaste tablets group and 2.80 for the conventional dentifrice group. No statistically significant differences were indicated between the two groups with respect to gingival or plaque index scores at baseline.

2-week data

Loe-Silness Gingival Index and Quigley-Hein Plaque Index - Table 2 presents a summary of the gingival and plaque index scores measured at 2 weeks for participants who completed the study. The mean 2-week gingival index scores were 1.34 for the toothpaste tablets group and 1.33 for the conventional dentifrice group. The mean 2-week plaque index scores were 2.56 for the

toothpaste tablets group and 2.59 for the conventional dentifrice group. No statistically significant differences were indicated between the two groups with respect to gingival or plaque index scores at 2 weeks.

Within group comparison

Loe-Silness Gingival Index and Quigley-Hein Plaque Index - Table 3 presents a summary of the within group analysis of the gingival and plaque index scores for participants who completed the study. The mean percent reductions of gingival index scores from baseline were 1.9% for the toothpaste tablets group and 0.8% for the conventional dentifrice group. Both reductions were not statistically significant at the 95% confidence level. The mean percent reductions of plaque index scores from baseline were 8.0% for the toothpaste tablets group and 7.8% for the conventional dentifrice group. Both reductions were statistically significant at the 95% confidence level.

Product use perception

Table 4 shows the perception on the use of dentifrice by

group. Pearson's Chi-Squared test showed that there were no statistically significant differences between the toothpaste tablets group and conventional dentifrice group for cleanliness, flavor, ease of use, eco-friendliness, switch to the current dentifrice, and overall satisfaction ($P > 0.05$, in all instances). However, there was a statistically significant difference in perception for "texture/foaminess", where there were more negative responses for the toothpaste tablets group (50%) as compared to the conventional dentifrice group (5%) ($P = 0.001$).

Discussion

With rising consumer awareness regarding oral hygiene and growing concern on sustainability, new innovative products and creative solutions are being developed. One such product is toothpaste tablets, which are solid tablets that turn into a slurry upon contact with water and saliva. Invented in Germany by Axel Kaiser in 2003, toothpaste tablets proved to rapidly dissolve in saliva, and demonstrate fluoride bioavailability that was higher immediately after tooth brushing and 10 minutes after tooth brushing compared to a conventional dentifrice foam/saliva mixture.¹⁶ More recently, toothpaste tablets have caught the attention of the public for offering many of the same benefits that conventional dentifrices do with minimal additives within the oral care product. A study on the abrasivity of toothpaste tablets reported another major benefit of toothpaste tablets. After simulated brushing for 415 days, toothpaste tablets, when compared to conventional dentifrice that had an RDA value below 250, showed significantly less abrasivity on dentin.¹⁷

To the best knowledge of the authors, this is the first registered randomized controlled trial that compared the use of toothpaste tablets to a sodium fluoride dentifrice for the control of supragingival plaque and gingivitis. Based on the results, we accepted our hypothesis. There was no difference in gingival index and plaque index scores between the two groups after 2-week usage indicating that toothpaste tablets were as effective as conventional dentifrice in controlling supragingival plaque and gingivitis. It is important to note that there was no significant reduction in gingival scores but a significant reduction of approximately 8% for plaque index scores in both dentifrice groups. The reduction is in alignment with another study that used Colgate Cavity Protection dentifrice and reported a plaque index score reduction of about 5% after 12 weeks of usage.²¹ The second hypothesis, perception of toothpaste tablets on cleanliness to overall satisfaction was comparable to conventional dentifrice, was partially accepted; however, there was a more negative perception on toothpaste tablets' texture. This negative perception could be attributed to the fact that consumers are more familiar with the traditional form of dentifrice that comes in a smooth paste form and produces a foamy texture when brushed. Toothpaste tablets, on the other hand, are often described as gritty or grainy. This deviation from the norm may make them less appealing to consumers initially and warrant further manufacturing improvement in tablet texture.

The maintenance of an effective level of plaque control is vital for the prevention of periodontal disease. The major strength of the study was to demonstrate that the efficacy of toothpaste tablets in controlling gingivitis and plaque was equivalent to conventional dentifrice containing the same con-

centration of 0.243% sodium fluoride. Limitations included the short duration of the study and limitations in generalizability as participants were healthy and young. Thus, there are several important aspects that should be considered in the future. Firstly, long-term studies are necessary to fully understand the impact of various types of toothpaste tablets on oral health. Secondly, a broader age range should be considered, including children and older adults, as oral healthcare products' needs and preferences can vary significantly across different age groups. Finally, it is important to include individuals with limited saliva flow, as they may face unique challenges in dissolving the tablets and require special instructions.

Toothpaste tablets are a relatively new form of toothpaste that offers a convenient and eco-friendly way of maintaining oral hygiene. Within the limitations of the study, we conclude that toothpaste tablets are a viable alternative to conventional dentifrice in reducing plaque with the added benefit of creating less waste.

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- b. Young Dental, Earth City, MO, USA.
- c. SPSS, Armonk, NY, USA.

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