A Comparison between Liquid and Conventional Toothpastes for Plaque Removal Effectiveness: A Crossover Randomized Controlled Trial

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Abstract

Objectives: To investigate the effectiveness of a liquid and a cream toothpaste on dental plaque score.

Methods: Thirteen subjects, aged 20-23 years old participated in this randomized controlled crossover clinical study. The study was conducted in 2 phases of 4-weeks each with a washout period of 1 week between phases. The subjects were randomized into two groups: Jintan-NUDE aqua mint® and Colgate Total Advance Fresh® and instructed to perform routine brushing with the assigned toothpastes. Total plaque scores (TPS) and proximal plaque scores (PPS) were assessed by one examiner using a Turesky's modification of the Quigley and Hein plaque index (TMQHI) 4 times during each phase: baseline (t_0), immediately after use (t_1), after the second week (t_2), and fourth week (t_3) of toothpaste use. Repeated ANOVA was used to compare the differences within each group and the paired t-test was used to compare the differences between groups at t_0, t_1, t_2, and t_3. The significance level was set at 0.05.

Results: The mean TPS and PPS of the groups were not significantly different at each evaluation point, except for the TPS of the liquid group at t_2, which was significantly higher than that of the cream group. The TPS and PPS in each group at t_1 were significantly lower compared with t_0, t_2, t_3 and the TPS of the liquid toothpaste group at t_2 was significantly higher than that at t_0. The differences between the other time points were not significant.

Conclusions: The cream toothpaste exhibited more plaque reduction than the liquid toothpaste at all time points measuring by the mean TPS and PPS. However, the difference was not statistically significant except for the second week's results.

Keywords: dental plaque, liquid toothpaste, plaque score, tooth brushing

Introduction

Dental plaque, the primary etiological factor for most dental diseases, is defined as "the diverse microbial community embedded in a matrix of host and bacterial polymers, growing on teeth as a biofilm".[1,2]

Mechanical cleansing by brushing with dentifrice is the most efficient method of plaque removal.[2] As most people experience difficulty in maintaining adequate levels of plaque control by mechanical cleansing alone especially on proximal surfaces, the use of additional chemicals for plaque control is required.[3] Dentifrice and mouthwash are the most common medium to transport the chemical adjuncts to the tooth surface, and then create direct inhibition on plaque formation.[4]

Recently, a new liquid toothpaste product has been introduced to the market. The manufacturer claims that its liquidity can better clean the proximal tooth surfaces, improve gingival health, and control bacterial growth compared with conventional toothpaste by imitating the mechanical effect of a mouthwash. A previous study showed that the mechanical effect of mouthwash alone can decrease bacteria in the oral cavity but the effectiveness of the reduction strongly comes from the antimicrobial agent.[5]

Plaque index scales show the visible amount of plaque on the tooth surface. It has been used as the primary endpoint of plaque control efficacy studies. Several crossover trials were carried out to evaluate plaque index after using assigned products.[7-9] Crossover design reduces subject variabilities and number of subjects.[7,9] The Turesky's modification of the Quigley-Hein plaque index (TQHPI) is an index commonly used that enables evaluation on both total and proximal plaque.[10]

Currently, there has been no study directly comparing the effectiveness of the new liquid toothpaste with a conventional toothpaste on its mechanical property as a better proximal plaque control. This study was conducted to compare the effectiveness on plaque removal between the liquid and conventional cream toothpastes. We hypothesized that liquid toothpaste will be as effective in plaque removal as a conventional toothpaste.

Materials and Methods

The protocol for this study was approved by the Ethics and Research Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2017-12). Informed consent was obtained from each volunteer prior to beginning of the study.

The subjects in this study were thirteen healthy volunteers between 20-23 years of age. All were second-to fourth-year dental students (11 females and 5 males) with medium-awareness on oral hygiene who met the inclusion criteria.

The inclusion criteria were good general health, non-smoking, and having at least 24 uncrowded teeth. The subjects who had visually detectable active caries, those who had gingivitis or periodontitis, those who had a fixed or removable dental appliance, and those who took antibiotics within 3 months prior to the study were excluded. The sample size was calculated from a pilot

study to include 19 subjects. However, due to a limited number of volunteers agreeing to participate throughout the 10-week study period, the number of the subjects who agreed to participate in the trial was 16.
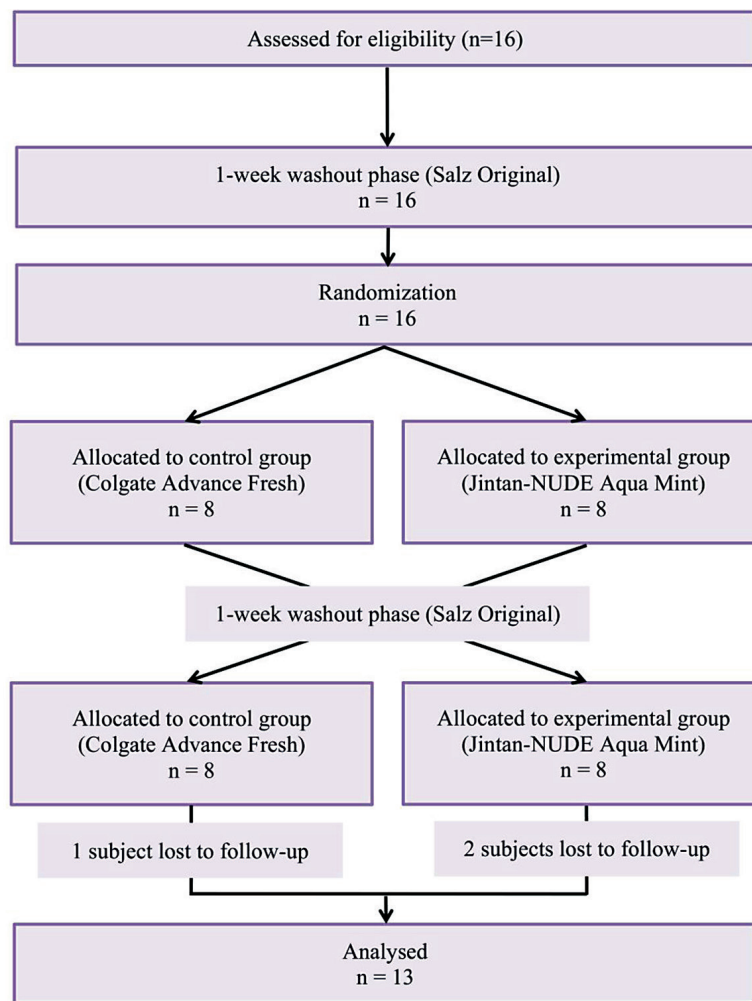
The study was designed as a randomized, single blind, crossover clinical trial to compare the effectiveness of two toothpastes (Figure 1), Jintan Nude liquid toothpaste (Thai-Jintan, Bangkok, Thailand) as an experimental group and Colgate Total Advance Fresh (Colgate Palm-Olive, Bangkok, Thailand) as a control group. The toothpastes' compositions are presented in Table 1. All oral examinations were performed at the Department of Pediatric Dentistry, Faculty of Dentistry, Chulalongkorn University.

Table 1: Toothpastes ingredients.

Toothpaste	Ingredients
Jintan-Nude	Water, Glycerin, Alcohol, PEG-60 hydrogenated castor oil, Sodium lauryl sulfate, Xanthan gum, Triclosan, Sodium bicarbonate, Ethylparaben, Dipotassium glycyrrhizate, Cl 42090, Cl 19140
Colgate Total Advanced Fresh	Sodium fluoride (0.24% (0.14% w/v Fluoride ion), Triclosan (0.30%). Water Hydrated Silica, Glycerin, Sorbitol, PVM/MA Copolymer, Sodium lauryl sulfate

Before starting the study, all subjects were instructed to brush with the modified Bass technique. The modified Bass brushing technique was taught to all the participants, and supervised brushing was carried out for 2 minutes. Subjects were given a non-triclosan pre treatment toothpaste (Salz original, Lion Corporation, Chonburi, Thailand) and a soft manual toothbrush with instructions to use only these products and to brush twice daily for 1 week. Subsequently, the subjects were scheduled for the first baseline examination (t_0) and asked not to perform any oral hygiene procedures in the previous 12 hours.

The examination comprised recording of their total plaque score (TPS) and proximal plaque score (PPS) by applying a dental disclosing agent (Erythrosine dye, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand) on their teeth and the subjects were asked to rinse with water. The scores were based on Turesky's modification of the Quigley-Hein plaque index (TQHPI)[11,12], using a mouth mirror and a dental explorer under optimal artificial lighting. Using the TQHPI, the

Figure 1: Diagram of the study.

jects were asked to brush at home with the assigned toothpaste for a 4-week period. In addition, the participants were instructed to brush their teeth for 2 minutes twice daily, in the morning and in the evening. Furthermore, the subjects were asked to refrain from using any oral hygiene products other than those assigned for the study. The first re-examination was done immediately after the first use of the assigned toothpaste at the same appointment for the baseline examination (t_1). The participants were rescheduled for re-examinations 2 and 4 weeks later (t_2 and t_3). Then the above-mentioned procedure was repeated after a washout period (1 week) in accordance with the crossover design, so that both products could be tested on each subject.

During the first phase, the subjects were requested to keep a food diary of what they ate, and use this list during the second phase to ensure that a similar diet was followed. The subjects were also asked to keep a record of their tooth brushing during each phase.

The examinations were performed by one blinded investigator (PB). Before the beginning of the study, the examiner was standardized and calibrated for TQHPI by an experienced pediatric dentist to ensure uniform interpretations, understandings, and application of the codes and criteria for consistent examination. In 20% of the subjects, the examination was redone 1 hour later to evaluate intra examiner reliability. The result was assessed using Cohen-Kappa statistics, which was found to be 97%.

Statistical analysis

The data were analyzed using SPSS version 19 software (SPSS Inc., Chicago, IL, USA). Normality test was performed using the Shapiro-Wilk test. The one-way repeated ANOVA was used to compare the differences in TPS and PPS among t_0, t_1, t_2, and t_3 timepoints in each toothpaste group followed by Bonferroni post-hoc analysis. The paired t-test was used to compare the differences in TPS and PPS between the two toothpaste groups at t_0, t_1, t_2, and t_3. The significance level was set at 0.05.

mesio-buccal, buccal, disto-buccal, mesio-lingual, lingual, disto-lingual surfaces of the teeth were scored as follows; score 0:no plaque/debris; score 1:individual flecks of plaque at the cervical margin of the tooth; score 2:thin continuous band of plaque (up to 1 mm) at the cervical margin of the tooth; score 3:a band of plaque wider than 1 mm but covering less than one third of the crown of the tooth; score 4:plaque covering at least one-third but less than two thirds of the crown of the tooth and 5 score: plaque covering two thirds or more of the crown of the tooth.

After the pre treatment period was completed, the subjects were randomly allocated to two groups of 8 subjects per group by a simple randomization. Each group was randomly assigned to one of the two toothpastes, Jintan Nude liquid toothpaste or Colgate Total Advance Fresh. The new soft manual toothbrush was given, the sub-

Results

The study began with 16 dental student participants, 3 dropped out due to loss to follow up so they were excluded from the study. Thirteen participants, 3 males and 10 females (23% and 77%), aged 21-23 years (average 22.31±0.85 years) completed the trial. The overall compliance rate of using assigned dentifrices is 98.44%. The results of TPS and PPS of both the liquid group and cream group are shown in Table 2 in mean (SD), range of plaque scores, and mean difference with 95% confidence interval.

For the comparison between time-points of each group, the mean TPS and PPS of each group showed statistically significant differences among time-points. The mean TPS of the liquid group at immediate use was significantly lower than the other time-points, while the mean TPS at 2 weeks and 4 weeks after using the assigned toothpaste were significantly higher than those examined at the baseline examination for the liquid group but not the cream group. No significant differences between the mean TPS between 2 weeks and 4 weeks after using both the assigned toothpastes were found ($p>0.05$). For the PPS of both the liquid and cream group, the mean PPS at immediate use was significantly lower than the other time-points. There was no statistically significant difference between PPS of other time-points for both toothpastes ($p>0.05$).

For the comparison between the types of toothpastes used, the mean TPS and PPS at baseline examination showed similar results for both the liquid and cream groups. The TPS and PPS of both groups immediately after the first use showed a reduction in plaque scores, a tendency that the cream toothpaste group exhibited more reduction than the liquid group, though the difference was not statistically significant ($p=0.495$, 0.133 for TPS and $p=0.916$, 0.156 for PPS, respectively). After using the liquid toothpaste for 2 weeks, it was found that the mean TPS and PPS were significantly higher than the cream group ($p=0.001$, <0.001, respectively). However, we did not find the difference in TPS and PPS at 4 weeks after using both assigned toothpastes ($p=0.229$, 0.262, respectively).

Discussion

The objective of this study was to compare the effectiveness of a highly advertised new liquid toothpaste and a conventional toothpaste on dental plaque score.

The finding supports our hypothesis that there was no difference in the plaque removal effectiveness between the liquid toothpaste and the conventional toothpaste.

The present study used a crossover study design. The same volunteer brushed with both the control and tested toothpastes, thus reducing the subject variability, i.e. brushing technique and diet.[7,9] Each participant was given a new toothbrush at the start of the experimental period and the amount of toothpaste used was prescribed. In addition, the participants were requested to complete a record of their diet during the first phase and followed similar diets during the second phase of the study. They were also requested to record their toothpaste usage to measure compliance, revealing the compliance rate was very high.

The results of the present study show that the cream toothpaste exhibited more plaque reduction measuring by the mean TPS and PPS than the liquid toothpaste at all time points measured. However, the difference was not statistically significant except for the second week's results.

Previous studies found that the use of dental products containing antibacterial agents significantly reduced plaque compared with products without antibacterial agents.[13,14] In the present study, both toothpastes contain triclosan, an antibiotic, as the main ingredient. Moreover, the participants were instructed to brush their teeth with either the liquid or cream toothpaste during the two phases. Mechanical cleansing alone reduces plaque scores much greater than a chemical agent.[15] Taken together, the toothpaste forms evaluated in our study may not have a differential effect on plaque scores.

After completing the trial, the participants provided additional comments on the difficulty experienced during the liquid toothpaste use, following its instruction to keep the liquid in the mouth during brushing. This uncomfortable procedure may be an explanation to the intragroup comparison where the liquid group showed significantly increased plaque score (both TPS and PPS) at t_2 and t_3 compared to baseline.

As all participants in this study were dental students, as such were more likely to maintain better oral hygiene compared with the general population, which may have resulted in a lower baseline plaque score. Furthermore, their increased awareness of brushing and oral hygiene may have affected the results of the study.

Table 2: Turesky's Modified Quigley-Hein Total Plaque scores and Proximal Plaque scores of the liquid and cream groups at different time points.

Group	TPS								p-value[2]
	t_0		t_1		t_2		t_3		
	Mean (SD)	Min, Max	Mean (SD)	Min, Max	Mean (SD)	Min, Max	Mean (SD)	Min, Max	
Liquid	1.85 (0.33)a	1.07, 2.31	0.72 (0.36)b	0.32, 1.40	2.36 (0.54)c	1.54, 3.26	2.22 (0.41)c	1.63, 2.91	<0.001
Cream	1.92 (0.32)a	1.44, 2.56	0.54 (0.31)b	0.83, 1.33	1.89 (0.44)a	1.40, 3.02	2.04 (0.38)a	1.37, 2.98	<0.001
Mean difference (95% CI)	-0.06 (-0.24, 0.12)		0.19 (-0.07, 0.44)		0.48 (0.25, 0.70)		0.18 (-0.13, 0.50)		
p-value[1]	0.495		0.133		0.001		0.229		
Group	PPS								p-value[2]
	t_0		t_1		t_2		t_3		
	Mean (SD)	Min, Max	Mean (SD)	Min, Max	Mean (SD)	Min, Max	Mean (SD)	Min, Max	
Liquid	2.72 (0.63)a	1.07, 3.47	1.01 (0.48)b	0.33, 1.63	3.30 (0.82)a	1.54, 4.88	3.13 (0.69)a	1.79, 4.37	<0.001
Cream	2.71 (0.60)a	1.57, 3.84	0.77 (0.48)b	0.13, 1.99	2.66 (0.78)a	1.40, 4.53	2.88 (0.71)a	1.78, 4.47	<0.001
Mean difference (95% CI)	0.02 (-0.33, 0.36)		0.24 (-0.12, 0.59)		0.65 (0.36, 0.93)		0.24 (-0.21, 0.69)		
p-value[1]	0.916		0.156		<0.001		0.262		

[1]*Differences between toothpaste group were performed using paired t-test.*

2Differences among time-points were performed using one-way repeated ANOVA followed by Bonferroni post-hoc analysis. Same lowercase superscript letter indicated no statistically significant difference between time-points (p>0.05).

t_0 = baseline examination, t_1 = immediately after the first use of the assigned toothpaste, t_2 = 2 weeks, t_3 = 4 weeks

TPS = total plaque score, PPS = proximal plaque score

A limitation of our study was the low number of participants. Due to the long-term involvement of the trial, only 13 participants completed the study. The crossover design was chosen due to smaller samples being required. It also reduced subject variability on oral hygiene behavior and routine habits. The low number of participants limited the statistical power and generalizability of the study's results.

Another limitation is that the subjects were not blinded to which toothpaste they were using due to the obvious forms of the test agents. This, combined with the situation in which subjects improve their tooth brushing due to awareness of being observed as participants of a study, may have resulted in reduced plaque scores unrelated to the toothpaste used.

Our study was the first study to compare the effectiveness of this new liquid toothpaste to the conventional toothpaste. Our suggestion is that future studies should be designed with a longer-term and a larger sample size to validate the present study's results. Moreover, additional parameters, such as the effect of the toothpastes on caries reduction or bleeding on probing, should be included in future studies.

Conclusions

The cream toothpaste exhibited more plaque reduction as measured by the mean TPS and PPS than the liquid toothpaste at all time points measured. However, the differences were not statistically significant except for the results of the second week.

Acknowledgements

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