Clinical evaluation of whitening effect of whitening toothpastes: A pilot study

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Abstract

Aim: The aim of this study was to compare the whitening effects of whitening toothpastes in a group of smokers and a group of non-smokers, over a four-week period, using toothpastes currently available to patients in Turkey. ***Methods***: Fifty-five volunteer dental students were selected according to the inclusion criteria and their tooth shade, which was either between Vita Lumen A2 and A3.5 or darker than A3.5. They were divided into two main groups: smokers and non-smokers. In the smoker groups (n=12), the students brushed their teeth with the BlanX® Intensive Stain Removal (n=6) or with Opalescence Whitening toothpaste (n=6). In the non-smoker groups (n=43), subgroups brushed their teeth with Opalescence (n=8), BlanX® Classic (n=10), Ipana 3D Whitening (n=8), Sensodyne Extra Whitening (n=9), or Colgate Total 12 Whitening (n=8) toothpastes. All students were required to brush their teeth twice a day with the same toothbrush, and whitening scores of the teeth were collected every Wednesday for four weeks from these individuals. Levels of whiteness were scored by two observers with reference to a Vita 3D shade guide. A four-week follow-up was performed. Data were entered into statistical software and tested using the chi-square test, Fisher's exact chi-square test, and the McNemar test. ***Results:*** Eighty per cent of all subjects' test teeth were whitened after four weeks. There was a statistically significant difference ($P<0.05$) between smokers and non-smokers after 28 days. One hundred per cent of smokers' test teeth were whitened as opposed to 75% of the test teeth of non-smokers. Of the test teeth, 70.45% were whitened by half a tone whereas the other 29.55% of them were whitened by one tone. ***Conclusion:*** It was concluded that although whitening toothpastes used in this pilot study had whitening effects on the teeth of both smokers and non-smokers over a four-week period, the numbers of smokers' teeth that were whitened were significantly greater than those of non-smokers.

Key Words: Whitening Toothpastes, Pilot Clinical Trial, Tooth Whitening, Vita Shade

Introduction

Tooth discoloration is a common dental complaint in most populations. Whitening of teeth is provided by dentists or other dental professionals but is more costly than whitening carried out by patients. As a result, there is interest in the development of methods for stain removal and tooth whitening that may be applied at home [1]. Today, in developed countries, most people brush their teeth and many appear to do so in order to have 'aesthetically beautiful teeth' when they smile.

The effectiveness of toothpastes at reducing or removing extrinsic dental stain has improved with the introduction of more whitening toothpastes onto the market [2]. A key feature of whitening toothpastes is that they include proteolytic enzymes that remove extrinsic stains from teeth. It is claimed that some whitening toothpastes also remove pellicle (external membrane) from a tooth surface [3]. Apart from containing whitening agents, whitening toothpastes also commonly contain bicarbonates and fluoride to promote caries protection. In Turkey, it has been suggested that further clinical studies are required to help clinicians decide exactly which whitening toothpaste(s) to recommend to patients [4].

A cursory appraisal of the ingredients suggests that most whitening toothpastes are formulated to control extrinsic dental stain rather than to change the natural colour through a bleaching action [5]. The market continues to expand as more tooth whitening dentifrices become available and clearly it is important to evaluate these products. Many

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clinical techniques such as the Lobene Stain Index (1968) [6], the Shaw and Murray Stain Index (1977) [7], and the comparison of tooth colour with a Vita shade guide [8-10] have been used to investigate the reduction of extrinsic staining of teeth. Many clinical studies into the whitening effect of dentifrices have been reported, with study periods differing from two weeks to six months [11].

Aim

Against this background, the aim of this study was to compare the whitening effects of whitening toothpastes in a group of smokers and a group of non-smokers, over a four-week period, using whitening toothpastes currently available to patients in Turkey.

Methods

All dental students at the Faculty of Dentistry, University of Marmara, Turkey, were invited to take part in the study. Of these, 55 met the following inclusion criteria and took part in a four-week examiner-blind parallel clinical trial.

The inclusion criteria were:

1. Able to attend for the period of the trial.
2. Visible stain present on half of the teeth surveyed.
3. Not currently participating in any other trial/ study.
4. At least eight anterior teeth, without restorations.
5. Not wearing any oral prostheses.
6. No inadequate restorations or untreated caries.
7. Aged over 18 years.
8. Anterior teeth with a tooth shade that was either between Vita Lumen A2 and A3.5, or darker than A3.5.

The exclusion criteria were:

1. Pregnant or lactating.
2. Participation in a clinical pharmacology trial during previous three months.
3. Taking medication during the trial.
4. Any known serious systemic or oral disease.
5. Known sensitivity/allergy to oral hygiene products, mouthwashes, etc.
6. Dental treatment during the study period.
7. Use of chewing gum during the study period.
8. Presence of significant amounts of calculus.
9. Presence/susceptibility to oral ulceration.

Study design

The toothpastes used in this study were: Opalescence Whitening Toothpaste, BlanX Classic Toothpaste, BlanX Intensive Stain Removal Toothpaste, Ipana 3D Whitening Toothpaste, Sensodyne Extra Whitening Toothpaste, Colgate Sensational White Toothpaste. They were selected on the basis that they were available in Turkey, claimed to have whitening properties, and details of their ingredients were available. The active ingredients of the whitening toothpastes are listed in *Table 1.*

Table 1. *Toothpastes Used in the Study and Their Ingredients*

Subjects	Name	Manufacturer	Active ingredients
Non-smokers	Opalescence Whitening Toothpaste	Ultradent Products, Inc.	Silica, poloxamer, sodium lauryl sulphate, carbomer, sodium benzoate, splenda
	BlanX Classic Toothpaste	Guaber	Silica, sodium lauryl sulphate, cetraria islandica, sodium monofluorophsophate, mentha piperita, titanium dioxide
	Ipana 3D Whitening Toothpaste	Procter & Gamble	Hydrated silica, sodium lauryl sulphate, tetrapotassium pyrophosphate, disodium pyrophosphate, tetrasodium pyrophosphate, carbomer, triclosan
	Sensodyne Extra Whitening Toothpaste	GlaxoSmithKline	Hydrated silica, sodium hydroxide, sodium methyl cocoyl taurate, pentasodium triphosphate, titanium dioxide
	Colgate Total 12 Whitening Toothpaste	Colgate-Palmolive	Triclosan 0.30%, hydrated silica, PVM/MA copolymer, sodium lauryl sulphate, sodium hydroxide
Smokers	Opalescence Whitening Toothpaste	Ultradent Products Inc.	Silica, poloxamer, sodium lauryl sulphate, carbomer, sodium benzoate, splenda
	BlanX Intensive Stain Removal Toothpaste	Guaber	Silica, sodium lauryl sulphate, cetraria islandica, usnea barbata, bambusa arundinacea, sodium monofluoro-phosphate, mentha piperita, titanium dioxide

The subjects were randomly allocated to seven groups as follows:

Non-smoker groups:

Group A: 8 subjects using Opalescence Whitening Toothpaste (OWT).

Group B: 10 subjects using BlanX Classic Toothpaste (BCT).

Group C: 8 subjects using Ipana 3D Whitening Toothpaste (I3DWT).

Group D: 9 subjects using Sensodyne Extra Whitening Toothpaste (SEWT).

Group E: 8 subjects using Colgate Sensational White Toothpaste (CSWT).

Total: 43 subjects

Smoker groups:

Group F: 6 subjects using Opalescence Whitening Toothpaste (OWT).

Group G: 6 subjects using BlanX Intensive Stain Removal Toothpaste (BISRT).

Total: 12 subjects

The same toothbrushes (Colgate® 360° toothbrushes; Colgate-Palmolive, Istanbul, Turkey) were given to all 55 subjects to brush their teeth. Before starting the study, oral hygiene instruction was given to subjects, including toothbrushing times and technique. Subjects were instructed to brush their teeth twice a day, in the morning after breakfast and in the evening before sleeping. Subjects were not given any instructions about drinking and eating, and were allowed to follow their previous patterns for these activities.

Two experienced, trained examiners, who had achieved a 90% agreement during a pre-study calibration, performed oral soft tissue examinations and shade assessments at baseline. Shade assessments were made by comparing the shade tabs from a Vita shade guide (VITA Toothguide 3D-Master®, which included a bleached shade guide; Vita, Germany) with the facial aspects of the upper and lower canine teeth and selecting the closest matching shade. The tooth shades of the subjects were evaluated, near one window, between 10.00 and 12.00 am in natural light. The examiners reviewed each participant after 7, 14, and 28 days from baseline and recorded the whiteness of the test teeth. At each review, teeth were scored as 'teeth that were whitened', 'teeth that were not whitened', and 'previously whitened teeth that underwent further whitening'. Whitened was defined as a change of shade half a tone or one tone in the Vita Lumen shade of the four canine teeth.

Statistical analysis

Data from the study were entered into statistical software (SSPS for Windows, Version 15.0; SPSS Inc, Chicago, USA). The chi-square test, Fisher's exact chi-square test, and the McNemar test were used to compare the quantitative data from the study. Results were tested for significance at the $P<0.05$ level.

Prior ethical approval is not required in Turkey for non-invasive studies such as the study reported in this paper.

Results

The numbers and percentages of all subjects and their distribution according to smoking habits,

Table 2. *Subgroups and Whitening Changes Over 28 Days*

		n (%)
Groups	Smoking	12 (22)
	Non-smoking	43 (78)
Whitening toothpastes	Opalescence (smoker)	6 (11)
	Opalescence (non-smoker)	8 (14)
	BlanX Intensive Stain Removal (smoker)	6 (11)
	BlanX Classic (non-smoker)	10 (19)
	Ipana (non-smoker)	8 (14)
	Colgate (non-smoker)	8 (14)
	Sensodyne (non-smoker)	9 (17)
Gender	Male	22 (40)
	Female	33 (60)
Results	Subjects whose teeth were whitened	44 (80)
	Subjects whose teeth were not whitened	11 (20)
	Subjects whose teeth were whitened half a tone	31 (70)
	Subjects whose teeth were whitened one tone	13 (30)

whitening toothpaste type, and gender are shown in *Table 2*. Eighty per cent of all subjects' test teeth were whitened after 28 days of brushing with a whitening toothpaste. Of these whitened teeth, 70.45% were whitened half a tone and 29.55% of them were whitened one tone.

Between baseline and day 7, four of the smokers' test teeth and 21 of the non-smokers' test teeth were whitened. By day 14, the teeth of eight of the smokers and 26 of the non-smokers had whitened. There was no statistically significant difference between the number of smokers' and non-smokers' test teeth that had whitened at the end of day 7 ($P>0.05$) and day 14 ($P>0.05$). There was a significant difference in the number of teeth whitened between the two groups between day 14 and day 28. By day 28, all smokers' test teeth were whitened whereas there were still 11 subjects with test teeth that were not whitened in non-smokers' groups ($P<0.01$). By day 28, there was a significant difference ($P<0.05$); that is, 12 of 12 smokers' test teeth were whitened and 32 of 43 non-smokers' test teeth that were whitened. When the whitening shade tones were compared, seven of the smokers' and 24 of the non-smokers' test teeth were whitened half a tone and five of the smokers' and eight of non-smokers' test teeth were whitened one tone *(Table 3)*.

In non-smoker groups, there was no significant difference between number of subjects with whitened teeth that were brushed with OWT, BCT, SEWT, CSWT and I3DWT by days 7, 14, and 28 ($P>0.05$). By day 28, seven of eight OWT, nine of ten BCT, six of nine SEWT, five of eight CSWT, and five of eight I3DWT groups' test teeth were whitened. There was also no significant difference between numbers of whitened test teeth in the five non-smoker subgroups, each of whom used different toothpastes to those used in the non-smoker group *(Table 4)*.

Table 3. *Comparison of Whitening Results of Smokers' and Non-Smokers' TeethSubgroups and Whitening Changes Over 28 Days*

All subjects				
Time	**Whitening categories**	**Smokers**	**Non-smokers**	
		n	**n**	*P*
Days 0-7	Number of subjects whose teeth were whitened	4	21	*0.416*
	Number of subjects whose teeth were not whitened	8	22	
Days 7-14	Subjects with teeth that had previously whitened, which underwent further whitening	1	7	*0.724*
	Subjects with teeth that had not whitened between baseline and day 7, which whitened for the first time between days 7 and 14	4	3	
	Subjects with teeth that had not whitened between baseline and day 14	4	17	
	Subjects with teeth that had previously whitened between baseline and 7 day; no further whitening between days 7 and 14	3	16	
Days 14-28	Subjects with teeth that had previously whitened, which underwent further whitening	5	-	*0.001***
	Subjects with teeth that had not whitened between baseline and day 14, which whitened for the first time between days 14 and 28	4	5	
	Subjects with teeth that had not whitened between baseline and day 28	-	14	
	Subjects with teeth that had previously whitened between baseline and day 7; no further whitening between days 14 and 28	3	24	
Results	Number of subjects whose teeth were whitened	12	32	*0.029**
	Number of subjects whose teeth were not whitened	-	11	
	Number of subjects whose teeth were whitened half tone	7	24	
	Number of subjects whose teeth were whitened one tone	5	8	

Chi-square test used. **P<0.05 ** P<0.01*

Table 4. *Whitening Evaluation of Non-Smokers' Teeth According to Different Types of Toothpastes and DaysSubgroups and Whitening Changes Over 28 Days*

Non-smokers							
Time	**Whitening categories**	**Whitening toothpastes**					
		OWT	**BCT**	**SEWT**	**CSWT**	**I3DWT**	
		n	**n**	**n**	**n**	**n**	*P*
Days 0-7	Number of subjects whose teeth were whitened	5	7	2	2	5	*>0.05*
	Number of subjects whose teeth were not whitened	3	3	7	6	3	
Days 7-14	Subjects with teeth that had previously whitened, which underwent further whitening	4	2	1	-	-	*>0.05*
	Subjects with teeth that had not whitened between baseline and day 7, which whitened for the first time between days 7 and 14	-	1	2	-	-	
	Subjects with teeth that had not whitened between baseline and day 14	1	2	5	6	3	
	Subjects with teeth that had previously whitened between baseline and 7 day; no further whitening between days 7 and 14	3	5	1	2	5	
Days 14-28	Subjects with teeth that had previously whitened, which underwent further whitening	-	-	-	-	-	*>0.05*
	Subjects with teeth that had not whitened between baseline and day 14, which whitened for the first time between days 14 and 28	-	1	2	2	-	
	Subjects with teeth that had not whitened between baseline and day 28	1	1	3	4	5	
	Subjects with teeth that had previously whitened between baseline and day 14; no further whitening between days 14 and 28	7	8	4	2	3	
Results	Number of subjects whose teeth were whitened	7	9	6	5	5	*>0.05*
	Number of subjects whose teeth were not whitened	1	1	3	3	3	

In smoker groups, the use of both BISRT and OWT resulted in whitening of the test teeth. By day 28, all 12 (100%) of the smokers' test teeth were whitened. There was no significant difference by days 7, 14 and 28 between BISRT and OWT for whitening of test teeth *(Table 5).*

Discussion

In this pilot study, whitening scores were evaluated to assess the validity of whitening toothpaste advertisements claiming that whitening will be observed after four weeks' use of whitening toothpaste. The whitening effects of the toothpastes were compared during this short period.

The Vita shade visual assessment has previously been used successfully in many clinical studies [12-16]. It was therefore used in this pilot study. The VITA Toothguide 3D-Master®, which included bleached shade tabs, was used because the shade change achieved by whitening toothpastes is less than that resulting from bleaching agents.

In the present study, six whitening toothpastes were evaluated. Previous studies have reported that whitening dentifrices produce a greater reduction and/or inhibition in extrinsic staining of natural teeth than standard commercial toothpaste formulations [17-19]. The active ingredients of toothpastes either include enzymes that dissolve pellicle proteins and inhibit staining, or contain chelating agents that have stain-dissolving properties.

In the smoker group, 100% whitening was achieved by both OWT and BISRT, both of which have a chemical stain-removal ability in their composition [20-22]. According to Sharif et al. (2000), only a small number of the whitening toothpaste products have good chemical stain-removal poten-

Table 5. *Whitening Evaluation of Smokers' Teeth According to Different Types of Toothpastes and Days*

Smokers				
Time	**Whitening categories**	**Whitening toothpastes**		
		OWT	**BISRT**	
		n	**n**	*P*
Days 0-7	Number of subjects whose teeth were whitened	2	2	-
	Number of subjects whose teeth were not whitened	4	4	
Days 7-14	Subjects with teeth that had previously whitened, which underwent further whitening	1	-	*>0.05*
	Subjects with teeth that had not whitened between baseline and day 7, which whitened for the first time between days 7 and 14	1	3	
	Subjects with teeth that had not whitened between baseline and day 14	3	1	
	Subjects with teeth that had previously whitened between baseline and 7 day; no further whitening between days 7 and 14	1	2	
Days 14-28	Subjects with teeth that had previously whitened, which underwent further whitening	5	-	*>0.05*
	Subjects with teeth that had not whitened between baseline and day 14, which whitened for the first time between days 14 and 28	-	4	
	Subjects with teeth that had not whitened between baseline and day 28	-	-	
	Subjects with teeth that had previously whitened between baseline and day 7; no further whitening between days 14 and 28	1	2	
Results	Number of subjects whose teeth were whitened	6	6	-
	Number of subjects whose teeth were not whitened	-	-	

tial; the majority are unlikely to achieve their claimed benefits through chemical stain removal [23]. However, in the years since the publication of the Sharif et al. (2000) report, it is probable that the composition of at least some whitening toothpastes has been changed to address this failing.

Alumina, dicalcium phosphate dihydrate, and silica are some of the abrasives that are included in whitening toothpastes [1]. Hydrated silica has been shown to have great cleaning and stain-removal ability [24]. All six toothpastes include similar ingredients, as shown in *Table 1,* and their common abrasive is hydrated silica; consequently, the whitening results for each toothpaste were similar in non-smoker groups.

Some of the whitening toothpastes contain a white pigment, titanium dioxide, designed to enter surface irregularities to give the illusion of whitened teeth [25]. SEW, BISR, and BCT contain titanium dioxide. SEW does not contain sodium lauryl sulphate (SLS) as a detergent; it contains titanium dioxide and hydrated silica. This is perhaps why in the non-smoker group there was no significant difference between the whitening toothpastes.

Triclosan helps to inhibit plaque and gingivitis. I3DWT and CSWT include triclosan. CSWT contains polyvinylmethyl ether/maleic acid (PVM/MA) copolymer that supports triclosan effects continuously [26]. I3DWT and CSWT produced the same whitening scores. However, for reasons unknown, these two toothpastes did not whiten the teeth of three subjects in the non-smoker group.

Forward et al. (1997) reported that toothpastes had complex and differing recipes, and that (in 1996) some specific active ingredients in the toothpastes were not listed by their manufacturers [27]. This may still be the case but the manufacturers of the whitening pastes assessed in this study appeared to have listed all the active ingredients in their pastes.

It has been suggested that another factor for whitening effect of toothpaste is pH. Price et al. (2000) reported that whitening toothpastes had a mean pH of 6.83 (range 4.22 to 8.35) [28]. The current study did not evaluate the pH of the whitening

toothpastes that it assessed. It is possible that slight differences in the whitening ability of the pastes that were evaluated may have been due to their different pH values.

The abrasive in toothpastes should ideally provide stain removal without causing wear of the tooth [29]. Lima et al. (2008) reported that the enamel wear caused by these dentifrices still needs to be assessed before they are recommended for routine use [30]. In future studies, this criterion may be added for the evaluation of whitening toothpastes.

Finally, it should be noted that no adverse reactions were reported by the subjects in this study, confirming that the formulations were well tolerated by the oral and peri-oral soft tissues and that the results of the present study paralleled those of previous clinical trials of whitening toothpastes.

Conclusion

It was concluded that the whitening toothpastes used in this pilot study had whitening effects on the teeth of both smokers and non-smokers over a four-week period. In smoker groups, whitening continued over four weeks. In addition, this pilot study has shown that there is a need for more clinical trials of whitening toothpastes. In such trials, both the number of participants and the length of time that the toothpastes are used should be increased. The abrasive effect and pH of the toothpastes and their active ingredient should also be taken into account.

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