



## Evaluation of the effect of teeth whitening strips on dental plaque pH

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### ABSTRACT

**Background and aim:** The present study aimed to assess the effect of teeth whitening strips on dental plaque pH in vivo.

**Materials and methods:** This in vivo experimental study was conducted on 21 individuals, who were requested to use Crest 3D whitening strips for 30 minutes once a day and for 14 days according to the manufacturer's instructions. Dental plaque pH was measured using GC plaque indicator kit at baseline (before using the strip), immediately after use (upon removal of the strip), and 30 minutes after the treatment at days one, seven and 14 following the onset of bleaching treatment. The data were analyzed using Freidman test, while Dunn's post-hoc analysis was used for complete comparison.

**Results:** At days one, 7 and 14, the plaque pH decreased immediately after the completion of the treatment compared to the baseline value, and this reduction was statistically significant ( $p=0.001$ ). The pH increased to the baseline value after 30 minutes. The plaque pH decreased at the 14th day in comparison with the first day, and this reduction was statistically significant ( $p=0.008$ ).

**Conclusion:** the results of the present study showed that application of whitening strips decreases the plaque pH immediately after the completion of the treatment; however, 30 minutes after strip removal, the pH reaches the baseline level. The plaque pH decreased during the two-week treatment period; however, it did not reach the critical pH.

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## Introduction:

Vital tooth bleaching was first introduced in 1868, and has gained increasing popularity since then.<sup>(1)</sup> The home bleaching technique was first introduced to esthetic dentistry in 1989 and since then, Carbamide Peroxide (CP) has been commonly used for this purpose. Despite some insignificant side effects, the efficacy and safety of CP-containing bleaching agents have been well documented.<sup>(2-5)</sup>

Bleaching trays are conventionally used for home bleaching. Teeth whitening strips were introduced to the market to overcome the shortcomings of the tray-based technique with reportedly easier use and superior efficacy.<sup>(6,7)</sup> Teeth whitening strips available in the market have 0.1 to 0.2mm thickness and contain 6% and 14% hydrogen peroxide (HP). These strips are made of polyethylene and are flexible. They adhere to labial surfaces of the teeth and release active whitening agents (for 5 to 60 minutes). They must be used once or twice a day for 14 to 28 days to exert their whitening effect. The whitening efficacy of these strips has been reported to be equal to that of bleaching trays containing 10% CP<sup>(8)</sup>; however, use of tray is often associated with greater postoperative tooth hypersensitivity.<sup>(9)</sup> It should be noted that 10% CP gel contains 3.3% HP, which is half the concentration of HP in the strips (6%); however, a higher volume of gel is placed in the tray compared to the active ingredients present in the strips. Due to easy use, availability, low cost and optimal esthetic results, whitening strips have become increasingly popular in the United States.<sup>(10)</sup> Also, the whitening potential of these strips is higher than that of other over-the-counter (OTC) tooth whitening products such as mouthrinses and gels.<sup>(7)</sup>

Tooth bleaching agents have different pH values depending on their chemical formulation.<sup>(11)</sup> However, OTC bleaching agents often have a low pH.<sup>(12)</sup> The changes in the plaque pH following the use of bleaching agents can alter enamel structure and can lead to initiation or cessation of carious lesions development, increasing the surface roughness while decreasing the surface hardness.<sup>(13)</sup> One study showed a significant increase in the pH of dental plaque and saliva fol-

lowing the use of 10% CP for dental bleaching<sup>(14)</sup>, while another study reported increased accumulation of dental plaque following a five-day period of no tooth brushing after tooth bleaching with 35% HP.<sup>(15)</sup>

Evidence shows that bleaching agents including whitening strips can cause changes in tooth structure.<sup>(16,17)</sup> However, some other studies have reported that the changes in tooth structure due to application of whitening agents are insignificant.<sup>(18)</sup> Considering the lack of information on the effects of whitening strips on dental plaque pH, this study aimed to assess the effect of Crest 3D whitening strips on dental plaque pH in vivo.

## Materials and methods:

This experimental in vivo study was conducted on 21 individuals, who were selected from among the students of the dental school of Islamic Azad University, using consecutive sampling. The inclusion criteria were the age range of 20-24 years, absence of periodontal disease, caries or dental restorations and willingness to use whitening strips. The study protocol was approved by the ethics committee of the university, and the participants signed written informed consent forms. The sample size was calculated based on a pilot study with the ethics code IR.IAU.DENTAL.REC.1395,24.

The participants were requested to refrain from eating, drinking, using mouthwashes or tooth brushing for two hours prior to the experiment. Plaque pH was measured at the baseline using a plaque indicator kit (GC, Suzhou, China). The plaque was collected from the cervical area of second right mandibular premolar. Immediately prior to plaque sample collection, an air syringe was used to lightly dry the sampling site to reduce the risk of contamination with saliva. The plaque sample was dipped for 1 second into an indicator solution and was observed after 5 minutes and its color was checked. The color should be compared with the testing chart available in the package as follows: Green (pH>6.8), yellow (6.4<pH<6.8), orange (5.8<pH<6.4), and red (pH<5.8). The participants were then instructed on how to use whitening strips (Crest 3D White Advanced Vivid White strips, OH, USA)

and were requested to use the strips for 30 minutes once a day and for 14 days. After 30 minutes, the strip was removed from the mouth and the plaque pH was measured immediately after removal of the strip, and also 30 minutes later at days one, seven and 14.

The collected data were analyzed using Friedman test, while Dunn's post-hoc analysis was used for complete comparison.

**Result:**

Friedman analysis showed that at the first day, the plaque pH decreased immediately after the completion of the treatment compared to the baseline value (p=0.001). Also, at days 7 and 14, the plaque pH decreased immediately after the completion of the treatment compared to the baseline value (p=0.002). 30 minutes after the treatment, the plaque pH increased to the level of the baseline pH at days one, 7 and 14. The results are presented in Table 1.

Assessment of the baseline plaque pH with Dunn's test showed that the baseline plaque pH at the 14th day was lower than that at days one and 7, and this reduction was statistically significant (p=0.005). However, the reduction in the baseline plaque pH at the 7th day was not significant compared to the first day (P=0.547).

At the 14th day, the plaque pH immediately after the treatment was lower than that at the first and 7th days, and this difference was statistically significant (P=0.032). The plaque pH 30 minutes after the treatment at the 14th day was lower than that at the first and 7th days, and this difference was statistically significant (P=0.008). (Tables 2, 3 and 4)

**Table 1- Plaque pH at days one, 7 and 14, at three different time intervals (baseline, immediately, and 30 minutes after the treatment)**

Day		Green(pH>6.8)	Yellow(6.4<pH<6.8)	Orange(5.8<pH<6.4)	Red(pH<5.8)	p. value
1 <sup>st</sup>	Before	8	10	3	---	.001
	After	1	9	8	3	
	30 minutes later	7	10	3	1	
7 <sup>th</sup>	Before	6	11	3	1	.002
	After	3	8	7	3	
	30 minutes later	8	7	6	---	
14 <sup>th</sup>	Before	1	10	10	---	.002
	After	---	6	9	6	
	30 minutes later	2	8	9	2	

**Table 2- Comparison of the plaque pH at days one, 7 and 14, at the baseline (before the treatment)**

Sample \ pH	Green(pH>6.8)	Yellow(6.4<pH<6.8)	Orang(5.8<pH<6.4)	Red(pH<5.8)	p. value
1 <sup>st</sup>	8	10	3	-----	.005
7 <sup>th</sup>	6	11	3	1	
14 <sup>th</sup>	1	10	10	-----	

**Table 3- Comparison of the plaque pH at days one, 7 and 14, immediately after the treatment**

Sample \ pH	Green(pH>6.8)	Yellow(6.4<pH<6.8)	Orang (5.8<pH<6.4)	Red (pH<5.8)	p. value
1 <sup>st</sup>	1	9	8	3	.032
7 <sup>th</sup>	3	8	7	3	
14 <sup>th</sup>	-----	6	9	6	

**Table 4- Comparison of the plaque pH at days one, 7 and 14, 30 minutes after the treatment**

Sample \ pH	Green(pH>6.8)	Yellow(6.4<pH<6.8)	Orang(5.8<pH<6.4)	Red(pH<5.8)	p. value
1 <sup>st</sup>	7	10	3	1	.008
7 <sup>th</sup>	8	7	6	-----	
14 <sup>th</sup>	2	8	9	2	

## Discussion:

The present study assessed the effects of teeth whitening strips on dental plaque pH, and showed that the use of whitening strips significantly decreases dental plaque pH at days one, 7 and 14, immediately after removal of the strip.

In this study, 3D White Advanced Vivid White strips were used, which contain 9.5% HP loaded on polyethylene strips. According to the material safety data-sheet, the pH of these whitening strips is 5.<sup>(19)</sup> These adhesive strips expose the labial enamel surface to the whitening agents loaded on the strips, which release HP shortly after contacting the teeth (for 5 to 60 minutes). Evidence shows that the whitening efficacy of these strips is similar to that of other tooth whitening products, except that postoperative tooth hypersensitivity is often greater after the use of tray-based systems, which may be attributed to the composition of the whitening agents used or to maladaptation of the tray margins with the soft tissue adjacent to the teeth.<sup>(20)</sup>

In the current study, the selected participants had relatively favorable oral hy-

giene and their baseline plaque pH values were above the critical pH of 5.5. The baseline plaque pH of the subjects at the first day ranged from 6 to 7.2. In 70% of the participants, the plaque pH was 6 to 6.6 prior to the treatment. This value significantly decreased after using the strips, which indicated the effect of time on the plaque pH changes following the use of bleaching agents. The duration of bleaching treatment in the current study was 14 days as recommended by the manufacturer, and the plaque pH did not decrease to below the critical pH during this period and remained in the range of 6 to 6.4. Hourizad and Heshmat evaluated the effect of whitening strips on the pH of saliva in vivo and found that despite the acidic pH of the strips (pH=5), no significant changes occurred in the salivary pH, which was attributed to the strong buffering capacity of saliva.<sup>(21)</sup>

Our results showed that the use of whitening strips for 14 days significantly decreased the dental plaque pH compared to day one, although this reduction did not reach the critical pH. According to the Stephan Curve, the plaque pH decreases faster than the salivary pH after exposure to acid, and slowly returns to the baseline value.<sup>(22)</sup> This faster reduction in the pH may be attributed to the

fact that dental plaque may serve as a barrier and may prevent the penetration of the saliva buffering system into the plaque.<sup>(22)</sup> Although the buffering capacity of saliva is lower in dental plaque, its effect is still obvious. The most important factor that prevents the reduction of the plaque pH to below the critical threshold ( $\text{pH} < 5.5$ ) is the saliva, as it contains calcium and phosphate ions. This is one of the reasons of the differences between in vivo and in vitro studies. In vitro studies always show higher roughness and different pH changes in comparison with in vivo studies.<sup>(23)</sup>

Leonard et al, evaluated the changes in the plaque pH following the use of 10% CP in night-guard bleaching of vital teeth, and concluded that the plaque pH and salivary pH significantly increased compared to the baseline values and remained high for two hours.<sup>(14)</sup> However, in the current study, the plaque pH decreased following the use of whitening strips. Such controversy in the results of the two studies may be due to the differences in the composition of the applied bleaching agents. Whitening strips contain HP, which has acidic pH due to the presence of conservatives. However, CP as a bleaching agent quickly breaks down into urea and HP, and urea increases the pH of the oral cavity to  $>8$  for a couple of hours.<sup>(24)</sup>

Lazarchik et al, Thomas et al, Zheng et al, and Ittatirut et al evaluated the effects of whitening agents on the salivary pH, plaque adhesion and cariogenic microorganisms and found that bleaching agents decreased plaque accumulation and cariogenic microorganism count.<sup>(25-28)</sup> Thus, in addition to their beneficial whitening effects, these compounds may be recommended to certain patients. On the other hand, HP compounds may change the structure of dental plaque due to their acidic nature.<sup>(13)</sup> According to Xu et al, the probable destructive effects of these strips on dental structure may be attributed to the reduction of the plaque pH following the use of these strips.<sup>(29)</sup> Thus, these products must be used cautiously under the supervision of dental clinicians. Considering the acidic nature of whitening strips, if they are used incorrectly by patients with poor oral hygiene without the supervision of dentists or accompanied by a nutritional regimen rich in carbohydrates or acidic drinks, the changes in the plaque pH may adversely affect the enamel structure and may make the teeth susceptible to caries.

Similar studies are required on the patients with high risk for caries. Also, assessment of the plaque pH for longer periods of time following the use of bleaching products is recommended. The effects of other OTC bleaching products on dental plaque pH should also be evaluated and compared with those of whitening strips.

### Conclusions:

Based on the results of the present study, application of bleaching strips decreases the plaque pH, although this reduction does not reach the critical pH. Nevertheless, it is necessary to consider the other factors that can decrease the plaque pH and increase the risk for caries during the bleaching period such as oral hygiene and nutritional regimen (use of acidic foods and drinks must be limited).

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