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Potential Side Effects of Whitening Toothpaste on Enamel Roughness and Micro Hardness

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Objective: Whitening toothpaste are easily obtained over the counter by consumers. The aim of this study was to assess the side effects of whitening toothpaste on enamel roughness and micro hardness which might contribute to increase caries risk.

Methods: Enamel specimens were obtained from 60 unidentified freshly extracted human premolars. The enamel specimens were randomly divided into three groups; whitening toothpaste containing perlite, whitening toothpaste containing ε-phtalimido peroxycaproid acid (EURECO® HC, Indonesia), and non-whitening toothpaste as control. Tooth brushing was performed equal to 1 and 3 months. Surface roughness tester was used to determine enamel roughness and Knoop Micro hardness tester was used to determine enamel micro hardness.

Results: There were statistically significant differences in enamel roughness after 1 and 3 months equivalent tooth brushing between three groups. There were significant differences in enamel micro hardness values for all groups after three months-brushing which showed a decrease in micro hardness for whitening groups and an increase in micro hardness for non-whitening group.

Conclusion: Tooth brushing with whitening toothpaste for a prolonged time increases enamel roughness and decreases enamel micro hardness, which in turn increases the potential of caries risk.

Keywords: dental caries, dental enamel, hardness tests, teeth whitening, toothpastes

Introduction

Due to the reported consumer and patient dissatisfaction with their perceived tooth color, toothpaste manufacturers have responded by developing a vast array of contemporary whitening toothpastes [1]. One of the key functional ingredients in whitening toothpastes is the abrasive system [2]. In general, these have been designed to give effective removal of extrinsic stains and help prevent tooth stains from reforming. The color of teeth are also determined by the effect of intrinsic color, which is influenced by light absorption properties of enamel and dentine with dentine having the major role in determining the overall tooth colour [3]. Intrinsic stain originated from deeper tooth surface and caused by hereditary disorder, medications, fluorosis and trauma. Extrinsic stain are located in tooth surface and these stains may be related to poor oral hygiene, smoking habit, and chromogenic food such as coffee and tea [4].

Tooth whitening treatment can broadly divided into two methods, tooth bleaching and routine prophylactic procedures

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such as brushing with whitening toothpaste. Tooth bleaching can improve intrinsic tooth color and typically contain hydrogen peroxide. Whitening toothpaste have formulations that have an enhanced physical and chemical cleaning ability. Whitening toothpaste have been shown to effectively remove and prevent extrinsic stain [2]. Because bleaching procedure is more expensive than prophylactic procedure using whitening toothpaste, many people choose to use whitening toothpaste than bleaching procedure. The whitening effects of whitening toothpastes are usually achieved by incorporation of bleaching and abrasive components. An ideal whitening toothpaste should remove stain effectively, whilst causing minimal effect on tooth structure. So, the effect of whitening toothpaste on enamel properties are important [4]. Micro hardness and roughness are two of the important properties of materials and associated with loss or gain of mineral content in tooth structure [5].

Materials and Methods

This was an in-vitro experimental study. The specimens were 60 unidentified freshly extracted human premolars (IRB No. 1337/PT02.H4.FKG/C3/2009 [Faculty of Dentistry, University of Indonesia]). All teeth were examined visually to ensure there were no caries, filling and fracture. The enamel specimens were embedded in acrylic mold and randomly divided into three groups (Table 1). Baseline data were collected for each sample before any intervention. Then tooth brushing was performed equal to 1 and 3 months. A typical tooth surface in vivo was brushed on average 5 seconds, twice a day [6]. Now, the specimens were brushed for 4 weeks, which equals 280 seconds and for 14 weeks, which equals 840 seconds. Surface roughness tester was used to determine enamel roughness and Knoop Micro hardness tester was used to determine enamel micro hardness. Moreover, data were analyzed using IBM SPSS ver. 20 (IBM Co., Armonk, NY, USA) and mean differences within groups were analyzed using Friedman test for enamel roughness average and one-way ANOVA test for micro hardness value. Mean differences between groups were analyzed using Kruskal-Wallis test for enamel roughness average and one-way ANOVA test for micro hardness value.

Results

The changes in enamel roughness values are described in Table 2. After tooth-brushing equal for 1 and 3 months, there were statistically significant differences in roughness average within three groups. Roughness average between three groups were not statistically significant different after 1 and 3 months tooth brushing. Mann-Whitney analysis showed that there were significant difference between group A with B and C, but no sig-

Table 1. Toothpaste used in the study

Group	Toothpaste	Ingredient
A	Pepsodent Whitening (whitening toothpaste with perlite abrasive)	Calcium carbonate, hydrated silica, 0.7% perlite, sodium lauryl sulphate, sorbitol, water, sodium silicate, cellulose gum, DMDM hydantoin, flavor, sodium saccharine, CI 74160, CI 77891, 1.12% sodium monofluorophosphate, potassium citrate
B	Formula Sparkling White (whitening toothpaste with peroxide)	Precipitated calcium carbonate, hydrated silica, sodium lauryl sulphate, sorbitol, purified water, PEG 600, sodium carboxymethyl cellulose, DMDM hydantoin, flavor, sodium saccharine, CI 74260, 0.1% ε-phtalimido peroxycaproic acid (EURECO® HC), monosodium phosphate, 0.8% sodium monofluorophosphate
C	Pepsodent Regular	Calcium carbonate, hydrated silica,sodium lauryl sulphate, sorbitol, water, sodium silicate, cellulose gum, DMDM hydantoin, flavor, sodium saccharine, CI 77891, 1.12% sodium monofluorophosphate, potassium citrate

Table 2. Enamel roughness average

Toothpaste group	Baseline	Month 1	Month 3	p-value
A (n=10)	0.09±0.32	0.19±0.11	0.41±0.24	<0.05
B (n=10)	0.07±0.04	0.13±0.10	0.22±0.19	<0.05
C (n=10)	0.07±0.03	0.12±0.05	0.20±0.08	<0.05
p-value	NS	NS	NS	

Values are presented as mean±standard error. A group: Pepsodent, Whitening (whitening toothpaste with perlite abrasive). B group: Formula, Sparkling, White (whitening toothpaste with peroxide). C group: Pepsodent, Regular. NS: not significant.

Table 3. Enamel micro hardness values

Toothpaste group	Baseline	Month 1	Month 3	p-value
A (n=10)	343.37±21.78	339.13±14.42	311.33±12.50	<0.05
B (n=10)	358.17±25.77	344.60±14.81	312.33±17.31	<0.05
C (n=10)	342.33±31.83	359.27±26.19	387.73±24.48	<0.05
p-value	NS	NS	<0.05	

Values are presented as mean±standard error. A group: Pepsodent, Whitening (whitening toothpaste with perlite abrasive). B group: Formula, Sparkling,White (whitening toothpaste with peroxide). C group: Pepsodent, Regular. NS: not significant.

nificant difference between B and C. The micro hardness values are described in Table 3. The one way ANOVA showed that statistically significant differences found in enamel micro hardness value among three toothpastes after three months brushing. Post Hoc least significant difference analysis showed that significant differences found in toothpaste A with C and toothpaste B with C. There were no significant differences in toothpaste A with B after three months brushing. Then, there were significant differences in enamel micro hardness value in baseline, after one month brushing and after three months brushing in all toothpaste groups.

Discussion

Whitening toothpaste can be easily acquired by patients who want to get whiter teeth at a lower cost. The main purpose of whitening toothpaste is removing stain, either mechanically or chemically. The mechanical ingredients in whitening toothpaste are abrasives such as hydrated silica, calcium carbonate, and perlite, which together with toothpaste bristles, remove the outer stained plaque, but do not change the color of teeth. Moreover, whitening toothpaste may contain bleaching agents, most commonly calcium peroxide or hydrogen peroxide to improve their ability to remove stain. They can break down the stain molecule, providing a bleaching effect. But, because of peroxide concentration in toothpaste are small and in contact with teeth for a short period of time, therefore there is lack of evidence about whether such toothpastes can improve the internal tooth color. They certainly bleach the pellicle or stain on the tooth surface [7]. An ideal whitening toothpaste should remove stain effectively, while have a minimal effect on tooth structure. So, the effect of whitening toothpaste on properties of enamel are important [4]. Roughness and micro hardness are two of the important properties of materials and associated with loss or gain of mineral content in tooth structure [5].

The increasing roughness average within three groups were caused by mechanism of active ingredients in the toothpaste, either mechanic or chemical agent. Toothpaste C as the positive control increased the enamel roughness because it contained abrasives, such as hydrated silica and calcium carbonate. Toothpaste B which contain the same abrasive and peroxide as the whitening agent had higher increasing roughness average, but not statistically significant different compared with toothpaste C after three-months tooth brushing. Toothpaste A which contain same abrasives and also perlite as the whitening agent had the highest increasing roughness. This is associated by the abrasion mechanism of abrasive particles that made scratches in enamel surfaces [8]. After three months tooth brushing, roughness average for paste A and B was 0.41 μm and 0.22 μm which had already passed the threshold for bacteria retention (0.20 μm) [8,9]. This could increase plaque formation, maturation and retention, which could lead to caries and periodontal inflammation risk, and could also contribute to teeth discoloration.

Although whitening toothpaste used daily remain in contact with teeth for a short period of time, is has been reported that frequent use may decrease enamel micro hardness [4]. Micro hardness determination can provide indirect evidence of demineralization and remineralization in dental hard tissues [10]. In this study, brushing the enamel specimens with perlite whitening toothpaste (toothpaste A) and peroxide whitening toothpaste (toothpaste B) caused a significant decrease in enamel micro hardness and brushing enamel specimens with conventional fluoride toothpaste without whitening active ingredients (toothpaste C) caused a significant increase in enamel micro hardness after 14 minutes brushing which equal to three months brushing in vivo.

In toothpaste A, there was a decrease in enamel micro hardness value. It means that, there was a mineral loss in enamel specimens brushed with toothpaste A. Demineralization caused by toothpaste A is associated with abrasion process by abrasives agents contained in toothpaste A, such as perlite, hydrated silica and calcium carbonate. A decrease in enamel micro hardness value in toothpaste B, besides the influence of abrasives (hydrated silica and calcium carbonate), is associated by the action of oxygen free radicals present in peroxide, which may react with mineral and organic structures of dental tissues [11]. Increasing enamel micro hardness value in enamel speci-

mens brushed with toothpaste C was caused by fluoride contained in toothpaste ingredients. Although all test toothpaste contain fluoride, only toothpaste C showed an increase in enamel micro hardness value. It means that remineralization rate in toothpaste C is higher than their demineralization rate caused by abrasives. In whitening toothpaste groups, demineralization rate is higher than remineralization rate. It is caused by whitening active ingredients in toothpaste A and B that cause a significant mineral loss.

Fluoride toothpastes have been used extensively and their anti-cariogenic properties have been evaluated through laboratory, clinical and epidemiological studies [12]. Nonethelles, tooth brushing with whitening toothpaste for a prolonged time has the potential to increases enamel roughness and decreases enamel micro hardness, which in turn increases the potential of caries risk. Moreover, the enamel integrity may be disrupted and dentin tubules may be exposed, resulting in dentin sensitivity [13].

Conclusion

This in vitro study demonstrated that prolonged use of tested whitening toothpaste causes increase in enamel roughness and decrease in enamel micro hardness. Therefore whitening toothpaste should be used with caution, due it's potential ability to increase the vulnerability of enamel surface and therefore increasing the risk of caries. Recommendation to use alternate whitening and non whitening tooth paste should be conveyed to consumers who have the willingness of using whitening toothpaste to decrease its potential defects to enamel.

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