Pharmacogn J. 2024; 16(1): 217-225
A Multifaceted Journal in the field of Natural Products and Pharmacognosy
www.phcogj.com

Research Article

Impact of Fluoridated Dental Products on Surface Roughness and Morphology of Bleached Tooth Enamel: An In Vitro Study

Mohammad H. Alsabeel[1,*], Aisha A. Qasim[2]

Mohammad H. Alsabeel[1,*], Aisha A. Qasim[2]

[1]*Kirkuk Health Directorate, Ministry of Health, Kirkuk, IRAQ.*

[2]*College of Dentistry, University of Mosul, Mosul, IRAQ.*

Correspondence

Mohammad H. Alsabeel

Kirkuk Health Directorate, Ministry of Health, Kirkuk, IRAQ.

E-mail: mohamad.21dep68@student.uomosul.edu.iq

History

- Submission Date: 11-12-2023;
- Review completed: 09-01-2024;
- Accepted Date: 18-01-2024.

DOI : 10.5530/pj.2024.16.31

Article Available online

http://www.phcogj.com/v16/i1

ABSTRACT

Purpose: To assess the impact of fluoridated dental products (Toothpaste, mouth rinse, and fluoride varnish) on bleached tooth enamel's surface roughness (SR) and surface morphology when used before, after, or before and after the tooth bleaching process. **Methods:** A total of (64) bovine permanent incisors were prepared and divided into two main groups: Group (A) was treated before and after the bleaching. Group (B) was treated after bleaching only. The bleaching process used an Opalescence boost of 40% hydrogen peroxide. Each main group was divided into (4) subgroups: (A1, B1) Control, (A2, B2) treated with FluorKIN mouthrinse, (A3, B3) treated with FluorKIN toothpaste, (A4, B4) treated with Proshield FV. A profilometer was used to evaluate surface roughness. Also, to assess the morphological changes in the enamel surface, another (14) teeth samples were viewed under the SEM. **Results:** There was a statistically significant increase in SR after bleaching and a decrease in SR after treatment, and there was no statistically significant difference between the group receiving bleaching only and the group receiving preventive protocol before bleaching, confirmed by SEM analysis. The slightest increase in surface roughness was found in the fluoride varnish group, followed by the FluorKIN toothpaste group, then the FluorKIN mouthrinse group. **Conclusion:** According to the surface roughness means results in the present study, Surface roughness increased very little in the fluoride varnish group, followed by the toothpaste group and mouthrinse group, respectively.

Keywords: Bleaching, Fluoride, Roughness, Morphology.

INTRODUCTION

Healthy, white, clean teeth can help enhance life, increase self-confidence, and decrease complaints. This depends on two factors; maintaining oral health through various methods, like tooth-brushing and flossing, and using cosmetic treatments to whiten teeth.[1] Both intrinsic and extrinsic stains are possible. Stains intrinsic to the tooth might be detected in the dentin underneath the enamel or in the enamel itself. Tetracycline incorporation, a range of metabolic illnesses, high fluoride intake during tooth growth (fluorosis), and other systemic and metabolic variables are all potential causes.[2]

The safest and most efficient technique to whiten teeth is tooth bleaching. Today's procedures for whitening teeth at home use trays and have low amounts of carbamide or hydrogen peroxide. In contrast, dental professionals put high concentrations of carbamide peroxide or hydrogen peroxide during in-office bleaching methods.[3] Despite the positive color change, peroxide-based whitening has been linked to adverse side effects, including demineralization, erosion, and tooth sensitivity.[4]

A decrease in microhardness and increased surface roughness values was observed as an adverse effect following the bleaching application.[5,6] The bleached enamel surface is susceptible to stains or discoloration from dark or colored fluids such as tea, coffee, juices, wines, and cola-based soft drinks. While some acidic solutions contain ethanol and/or pigments, others contain substances that may accelerate demineralization. Additionally, frequent use of tobacco products, artificial food colorings, and certain beverages are thought to be the primary causes of teeth discoloration, staining, and darkening.[7] Increasing enamel surface roughness promotes S. mutans adhesion to tooth enamel.[8] For these reasons, following bleaching, the damaged enamel surface needs to be restored.

The bleaching techniques erosive effects utilizing sodium fluoride-based (NaF) materials have been studied using various strategies.[4] Due to fluoride stimulation fluoride and calcium deposition on enamel surfaces, it was the first and most widely utilized substance in after-bleaching treatment.[9] Treatment with fluoride may lessen the harmful effects of bleaching agents. Calcium fluoride is created through the incorporation of fluoride ions into demineralized regions. Fluoride ions can also replace the enamel's apatite hydroxyl groups, producing fluorapatite as a result.[9] This significantly lowers mineral loss and restores microhardness[10] and roughness.[11]

The objectives of the following study are to assess the impact of fluoridated dental products (toothpaste, mouth rinse, and fluoride varnish) on bleached tooth enamel's surface roughness and surface morphology when used before, after, or before and after the tooth bleaching process.

MATERIALS AND METHODS

Teeth Samples Collection: Bovine incisors recently extracted were selected and donated from the slaughterhouses of Kirkuk governorate. The teeth were cleansed, rinsed with tap water, and then kept in a solution containing 0.1% thymol (Switzerland)

Cite this article: Alsabeel MH, Qasim AA. Impact of Fluoridated Dental Products on Surface Roughness and Morphology of Bleached Tooth Enamel: An In Vitro Study. Pharmacogn J. 2024;16(1): 217-225.

at 4ºC until use.[12,13] Among all the collected teeth, only Sixty-four were selected for roughness analysis, and an additional fourteen were selected for SEM analysis.

Teeth Samples Preparation: The roots were removed using a straight Diamond sectioning disc bur with a low-speed engine and continuous water cooling to prevent enamel damage after that, the teeth were carefully cleaned and polished using non-fluoridated pumice (Argentina).[14] Following that, the teeth crowns were embedded in blocks of auto-polymerized cold-cure acrylic resin (Acrosun, Betadent com. Iran).[15] Using 15 mm high cylindrical plastic tubes with flat, parallel upper and lower borders, the outer labial surface of the teeth is pointed upward. Each tooth's labial surface was ground and polished ten times in one direction with grit paper (grit 400, 600) (Saudi Arabia company) to create a flat and uniform enamel surface specimen for surface roughness testing.[14] Every sample was sanded using the same technique with new carbide silicon abrasive paper.[11] The samples spent ten minutes in an ultrasonic machine to remove residues.[16] By measuring the distance between the incisal edge and the cementoenamel junction, and the mesiodistal dimension, the middle third of the labial surface of the crown was marked using a caliper. On the labial surface of the samples, a (10×7 mm^2) adhesive tape was applied in the middle of the crowns. The crowns were painted with acid-resistant nail polish; after the samples had dried, the tapes were removed to reveal the enamel surface.[15]

Bleaching procedure: All bleaching procedures were done using Opalescence Boost, Ultradent, USA (40% Hydrogen peroxide) per the manufacturer's instruction—application of bleaching gel while taking into account the manufacturer's maximum recommended duration (3 x 20 minutes). The two syringes of bleaching material come together; one syringe contains 3% potassium nitrate and 1.1% sodium fluoride with a chemical activator, and the second contains hydrogen peroxide. Mixing materials was done by pressing the plunger of one syringe to push all content into the other; this was repeated 50 times to ensure good mixing. The concentration of HP after mixing is 40%.

A thin layer (0.5 -1 mm) of HP gel was applied to the enamel surface and left for 20 minutes with periodically checking and re-applying areas that had been thinned or needed replenishing; then this layer was washed with water and lightly air-dried; this procedure was repeated two additional times. The total period of the bleaching procedure was 1 hour.

Treatment Cycle: A total of (64) bovine permanent incisors were prepared and divided into two main groups: Group (A) was treated before and after bleaching. Group (B) was treated after bleaching only. Each main group was divided into (4) subgroups: (A1, B1) Control, (A2, B2) treated with FluorKIN mouthrinse, (A3, B3) treated with FluorKIN toothpaste, (A4, B4) treated with Proshield FV.

Subgroup 1 (Control group): Samples were immersed in distilled water with daily refreshment of solution during the experiment.

Subgroup 2 (Fluor KIN mouthwash): Samples were immersed in 10 ml of 0.05% NaF mouthwash (Fluor KIN mouthwash) for five minutes every 12 hours (twice a day), then without rinsing, samples were immersed in deionized water.[17]

Subgroup 3 (Fluor KIN toothpaste): Specimens were treated with Fluor KIN toothpaste every 12 hours for five minutes, then the paste was wiped with soft cotton without rinsing, followed by immersing specimens in deionized water.[17,18]

Subgroup 4 (Proshield varnish): Using a micro brush, the varnish was applied thinly, and the specimens were kept in deionized water. After six hours, the varnishes were delicately removed with a scalpel blade, being careful not to touch the enamel surface.[19]

All samples were rinsed with deionized water for a minute while not scratching the surfaces before beginning the treatment and bleaching cycle.[20,21]

Surface Roughness Test: Using a surface roughness tester (KR220, HFBTE, China), operating with the specimen surface in contact with the stylus, the surface roughness of the enamel surface of the samples was examined. Three distinct profilometric traces were taken on the enamel surface of each specimen, and the results were used to calculate the arithmetic mean deviation of the surface profile or Ra.[19] Each specimen's average Ra values were calculated using the following parameters: a 4-m diamond stylus, a 90° reading angle, a 0.25 mm cutoff length, and a 1.25 mm trace length.

The surface roughness test for group (A) was done at baseline, after initial treatment, after bleaching, and after final treatment. At the same time, surface roughness tests for group (B) were done at baseline, after bleaching, and after treatment.

Scanning Electron Microscopy Images (SEM): A scanning electron microscope (FEI, Inspect F50, The Netherlands) examined the enamel's surface morphology.

SEM Samples Preparation: A total of (14) whole bovine incisors were carefully selected for SEM analysis. Bovine incisors enamel blocks (5x5 mm) were obtained by sectioning the crown with a straight diamond sectioning disc using a low-speed dental engine with copious water irrigation for cooling to prevent damage to the enamel structure. The enamel blocks of the teeth were held in place by rubber rings that were 8 mm in height and filled with auto-polymerized cold-cure acrylic resin. The rubber rings on the blocks were removed to make them smaller so they could fit into the SEM holder. With unflavored, non-fluoridated pumice, the samples were cleaned and polished.

Observation with Scanning Electron Microscope: The samples were mounted on the SEM holder with their treated surfaces facing up for SEM observation using a removable adhesive. Using a sputter coater in a vacuum, a gold-palladium layer was applied to each sample, and it was then adjusted so that it could be observed with an SEM at an accelerating voltage of 8 kV. Photomicrographs were taken and digitally archived after the morphology of the enamel surfaces of the teeth was examined.

RESULTS

The initial step was to ascertain whether the data were normally distributed before running any tests. This was accomplished using the Kolmogorov-Smirnova and Shapiro-Wilk tests; parametric tests and one-way ANOVA were selected due to the normally distributed nature of the data.

Group (A) Roughness Results: The SR of the teeth between the groups receiving various remineralizing treatments of group (A). The results showed no statistically significant difference in the groups' SR at baseline and after the first treatment values. After bleaching, the highest SR mean value was found in the control group, which was no statistically significant difference from the mouthrinse group and no statistically significant difference between mouthrinse and toothpaste and FV groups. After the final treatment, no statistically significant difference between toothpaste and FV groups showed the lower SR mean and statistically significantly different to mouthrinse and control groups (Table 1).

Group (B) Roughness Results: SR of the teeth between the groups receiving various remineralizing treatments of the group (B). The results showed no statistically significant difference in baseline and after-bleaching values among the groups. After treatment, the toothpaste group was statistically non-significant different from the FV

Table 1. Means values, Standard deviation, and Duncan's Multiple Range tests of SR mean values of the variables between the subgroups of group (A).

Groups		Baseline	First treatment	After bleaching	Final treatment
	Mean	0.3327 a	0.3477 a	0.6655 a	0.6782 a
Control	N	8	8	8	8
	Std. Deviation	0.0358	0.0688	0.0347	0.0838
	Mean	0.3236 a	0.3046 a	0.6151 ab	0.5933 b
Mouthrinse	N	8	8	8	8
	Std. Deviation	0.0813	0.1016	0.0412	0.056
	Mean	0.3231 a	0.2943 a	0.6057 b	0.5022 c
Toothpaste	N	8	8	8	8
	Std. Deviation	0.0314	0.0221	0.0578	0.0706
	Mean	0.3302 a	0.2867 a	0.6071 b	0.4940 c
Varnish	N	8	8	8	8
	Std. Deviation	0.164	0.0771	0.0702	0.0505
	Mean	0.3274	0.3083	0.6233	0.5669
Total	N	32	32	32	32
	Std. Deviation	0.09	0.0737	0.0561	0.0991

N: Number of the specimens, Std. Deviation: Standard Deviation. Small letters indicate statistically significant differences within the same column (Vertically).

Table 2. Means values, Standard deviation, and Duncan's Multiple Range tests of SR mean values of the variables between the subgroups of group (B).

Groups		Baseline	After bleaching	After treatment
	Mean	0.3243 a	0.6451 a	0.6502 a
Control	N	8	8	8
	Std. Deviation	0.0328	0.0114	0.0138
	Mean	0.3332 a	0.6418 a	0.5676 b
Mouthrinse	N	8	8	8
	Std. Deviation	0.0312	0.0465	0.0776
	Mean	0.3341 a	0.6491 a	0.4776 c
Toothpaste	N	8	8	8
	Std. Deviation	0.0584	0.0667	0.0551
	Mean	0.3245 a	0.6473 a	0.4542 c
Varnish	N	8	8	8
	Std. Deviation	0.0348	0.1016	0.0793
	Mean	0.329	0.6458	0.5374
Total	N	32	32	32
	Std. Deviation	0.0391	0.0621	0.0987

N: Number of the specimens, Std. Deviation: Standard Deviation. Small letters indicate statistically significant differences within the same column (Vertically).

group, which showed the lowest mean values of SR, and was statistically significantly different from the control group, which showed the highest mean value of SR. The mouthrinse group differed statistically significantly from the control, toothpaste, and FV groups (Table 2).

Surface roughness (SR) at baseline, after bleaching, and after treatment protocols between A and B groups by independent sample T-test, and the results showed that there were no statistically significant differences $p > 0.05$ in each same subgroup at each stage of treatment (Table 3).

Scanning Electron Microscopy SEM: After applying different treatment strategies, morphological changes in enamel were evaluated using scanning electron microscopy (SEM).

DISCUSSION

Regarding both intrinsic and extrinsic aspects of tooth structure, mineral loss and erosive damage brought on by bleaching agents continue to be serious concerns.[22] The bleaching effectiveness and the intensity of adverse effects on the dental enamel may be affected by the bleaching agent's concentration, application method, and exposure duration.[5]

In the current study, the enamel's surface roughness significantly increased following 3 x 20 min application of the bleaching product (In-office Opalescence boost 40% hydrogen peroxide, 1.1% sodium fluoride, 3% potassium nitrate, pH adjuster, thickener), as the manufacturers recommend it. This result was in agreement with Bilge and Kilic (2021) study that found the fluoride content of the bleaching agent had no positive impact on the remineralization process.[11] A study by Wijetunga et al. (2021), demonstrated that the bleaching compounds with alkaline, neutral, and low pH could cause decreased microhardness, increased surface roughness, and enamel surface morphological alterations at different degrees with repeated bleaching applications, and these results in agreement with the current study since the bleaching agent PH used was neutral (7.0).[23]

Contrarily, numerous previous research discovered that even when using a high concentration of hydrogen peroxide, there were no appreciable changes in the surface roughness of enamel after the application of hydrogen peroxide.[24,25] Another study by Ittatirut et al. (2014), showed a marked reduction in the surface roughness of enamel following bleaching compared to the control.[26] However, findings from previous studies agreed with those of the current research,[5,27,28] where it was shown that the enamel surface had changed, and the surface roughness had increased after 40% hydrogen peroxide bleaching. The loss of interprismatic compounds and magnesium and sodium ions may cause this increased roughness.[27] According to other similar research, the micromorphological analysis of the bleached enamel results in pronounced prism abnormalities with high Ra mean values.[29]

In the current study, the remineralization materials used were commercially available oral health products that contain fluoride in different forms and concentrations to evaluate their action in preventing and treating increased surface roughness obtained after bleaching.

For group (A), according to the current study, there was no difference between the subgroups at baseline, after the first treatment, and after bleaching. In addition, following ’s final treatment, there was a highly significant difference between the subgroups at p≤0.01, Table 1. For this reason, at baseline, during the first treatment, and following bleaching, all groups were distributed homogeneously, since the Duncan multiple range analysis test revealed no significant difference between the groups. In contrast, the groups were non-homogeneously distributed after the final treatment. It was observed that fluoride varnish had the minimum SR mean value followed by the toothpaste group and mouthrinse group, respectively, and the deionized water control group had the highest Ra mean value.

The mean surface roughness values in the fluoride groups in the current investigation were lower than those in the control group (deionized water). This is consistent with the findings of other studies that demonstrated the ability of high fluoride concentration to protect enamel from erosion. Fluoride's proven capacity to form calcium fluoride has also been linked to the preventive effect that topical application of the fluoride has shown. Although calcium fluoride dissolves easily and slowly when exposed to acid, it does stop the mineral loss from enamel by acting as a physical barrier on the enamel surface.[32,32]

For group (B), according to the current study, there was no difference between the subgroups at baseline and after bleaching. In addition, after treatment, there was a statistically significant difference between the groups at p≤0.01, Table 2. So, all groups were distributed homogeneously at baseline and after bleaching as there was no significant difference between groups, as observed by the Duncan multiple range analysis test for groups. By contrast, Duncan's multiple-range analysis test for groups after treatment demonstrated that the groups were non-homogeneously distributed. It was observed that fluoride varnish had the lowest Ra mean value followed by toothpaste and mouthrinse groups, respectively, and the deionized water control group had the highest mean value.

Because fluoride supplements increase the amount of fluoride on the enamel surface, previous studies have demonstrated the potential preventive effects of fluoride against erosion. This event was most likely caused by the development of materials that like CaF2 on the enamel surface; it serves as a fluoride storage area and another mineral that can partially act as a physical barrier to prevent acid from touching the enamel below. Acid resistance results from the incorporation of fluoride released from the reservoir onto the enamel's outer surface through the formation of Fluorapatite crystals after an acid attack.[33,34]

The present study showed minor with no significant reduction in the roughness of intact enamel surface after remineralization with the three concentrations of fluoride; these results may be due to the already smooth enamel surface and high mineral content without porosities that may minimize fluoride penetration and decrease remineralization.

The minor differences in surface roughness for the sound enamel after applying different remineralizing agents could be associated with variations in the structure of the enamel. Because of mineral deposits in the oral environment, minor defects, pits, and Retzius grooves, the enamel surface has a naturally rough appearance,[35] grinding the enamel surfaces utilized in this study may have slightly increased the roughness, as reported in the Salama et al. (2020), study, and only the middle third of the buccal surface was used to have comparable zones from different teeth with similar chemical and physical characteristics.[35] Additionally, there are several ways in which the enamel structure affects the features of the surface (hardness and roughness), including differences in the

Table 3. Independent sample T-test for corresponding subgroups in groups (A and B) for SR mean values within tested groups at baseline, after bleaching, and after treatment.

			N	Mean	t-value	Sig.	SD
Baseline	Control	group A	8	0.3328	0.487	0.634	0.0359
		group B	8	0.3244	0.487	0.634	0.03285
	Mouthrinse	group A	8	0.3236	-.312-	0.759	0.08137
		group B	8	0.3332	-.312-	0.762	0.03122
	Toothpaste	group A	8	0.3231	-.469-	0.647	0.03141
		group B	8	0.3341	-.469-	0.649	0.05848
	Varnish	group A	8	0.3303	0.172	0.866	0.16402
		group B	8	0.32	0.172	0.868	0.03811
After bleaching	Control	group A	8	0.6655	1.575	0.138	0.03476
		group B	8	0.6451	1.575	0.152	0.01143
	Mouthrinse	group A	8	0.6151	-1.217-	0.244	0.04126
		group B	8	0.6419	-1.217-	0.244	0.04651
	Toothpaste	group A	8	0.6058	-1.389-	0.187	0.05783
		group B	8	0.6491	-1.389-	0.187	0.06676
	Varnish	group A	8	0.6071	-1.145-	0.271	0.08151
		group B	8	0.6474	-1.145-	0.272	0.10168
After treatment	Control	group A	8	0.6782	0.931	0.368	0.08384
		group B	8	0.6503	0.931	0.381	0.01385
	Mouthrinse	group A	8	0.5934	-.761-	0.461	0.05604
		group B	8	0.5676	-.761-	0.46	0.07765
	Toothpaste	group A	8	0.5022	-.777-	0.451	0.07069
		group B	8	0.4776	-.777-	0.45	0.0551
	Varnish	group A	8	0.494	-1.195-	0.255	0.05052
		group B	8	0.4542	-1.195-	0.252	0.07935

N: Number of the specimens, Std. Deviation: Standard Deviation. Std. Error Mean: Standard error mean.

alignment of the enamel prisms and sheath. Moreover, the anisotropic structure of enamel and the chemistry of the surface may contribute to changes in the enamel surface roughness, which have an impact on the qualities, such as a more mineralized outer surface (9%) than interior enamel following the eruption.[36] Furthermore, the mineral exchange between the oral environment and the enamel surface is related to the chemical changes in enamel may provide the effect.[37]

The surface roughness results showed a significant reduction in mean surface roughness for both groups (A and B) after remineralization with the three fluoride concentrations after bleaching, with some differences. These results agreed with Attin et al. (2007)[38] and Karlinsey et al.(2011) studies[39], they speculated that the fluoride uptake is higher in demineralized enamel compared to sound tissue because the increased erosion caused by bleaching treatment facilitates fluoride penetration, and consequently re-hardening and decreasing the surface roughness of enamel after bleaching.[40] The FV showed the most decrease in enamel roughness in both groups (A and B). According to some studies, the most effective remineralization agent is a 5% sodium fluoride varnish which is in agreement with our findings.[40-42] The high fluoride concentration of sodium fluoride probably induced the development of a calcium fluoride layer on the surface of the enamel. Later, this layer might have allowed the diffusion of fluoride ions diffusion and the bleached dental enamel remineralization.[43]

Beyond all else, it is essential to remember that fluoride varnish differs from toothpaste in terms of density, fluoride content, and application technique. This implies that varnishes stay on the tooth surface more consistently after application, providing better fluoride protection and absorption.[44] SEM evaluation of the enamel surface was required for further clarification of the surface roughness findings and was used by many studies.[11,23,45]

The original enamel surface was relatively flat, with smooth enamel surface morphology with minimal porosity incidence seen where the magnification used was 8000x and 15000x was used, as shown in Figure 1. The samples displayed the typical regular enamel pattern, smooth and relatively uniform, with perikymata expressing anatomical horizontal growth lines of enamel without polishing with grit paper. This result agrees with ElMoshy Abbas, who concluded that SEM results showed that the sound enamel has a smooth surface with some pits and scratches.[46]

The integrity of the enamel surfaces, however, was damaged to variable degrees after the pH-cycling phase (40% H_2O_2) due to the disintegration of the interprismatic structures and enamel prism cores, Figure 2. Demineralized interprismatic structures connected with demineralized enamel prism cores, create observable deep etched pits.[47] Ergucu et al. (2023), [45] and Bilge and Kilic (2021)[11] used SEM to examine the post-bleaching surface roughness. They discovered an increase in surface roughness after bleaching with 40% hydrogen peroxide within the same period of our study (3x20 minutes).

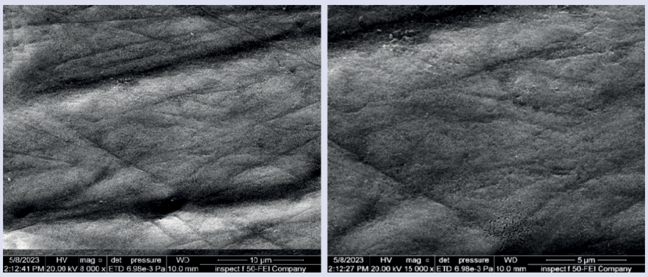


Figure 1. SEM images of the untreated enamel surface (control tooth) revealed a flat smooth enamel surface morphology, a small incidence of porosities, and the lack of surface deposits and cracks (A: 8000x, B: 15000x).

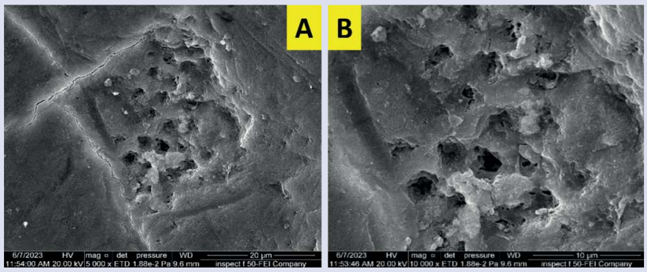


Figure 2. SEM images of the bleached enamel surface, Showed morphological changes with varying degrees of structure loss, including depressions, porosities, surface irregularities, and erosion changes with depressed enamel prism cores (A: 5000x, B: 10000x).

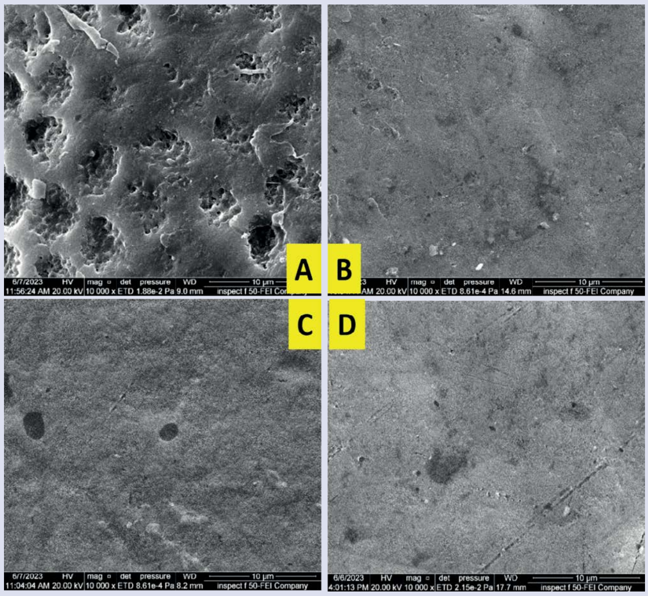


Figure 3. SEM images (10000x) of the enamel surface treated with **(A)** deionized water after bleaching (Control, BT1) displayed morphological alterations with varied levels of loss of structure, including depressions, porosities, and surface irregularities. **(B, C,** and **D)** were bleached with hydrogen peroxide 40% and treated with Mouthrinse, Toothpaste, and Fluoride varnish, respectively. The enamel surface of the specimens looks smooth in the generated photos that are most similar to the control group.

SEM images of the samples that were bleached with 40% HP and then treated with mouthrinse, toothpaste, and fluoride varnish revealed a smooth enamel surface with the absence of porosities, interprismatic and intraprismatic dissolution when compared with a control sample that bleached and then treated with DDW, Figure 3. These results came in agreement with Bilge and Kilic (2021) study that used SEM analysis, which showed that the bleaching effects on enamel structures could be reversed by using a remineralizing agent, turning deeper and irregular structures into shallow and more homogenous ones.[11] Additionally, this was supported by declining Ra values from profilometric measurements, which quantitatively show decreased surface roughness following remineralization.

SEM images were produced for the samples treated with mouthrinse, toothpaste, and fluoride varnish before the bleaching process to assess the preventive effect of fluoridated products on enamel surface morphology against the harmful impact of bleaching, Figure 4. These

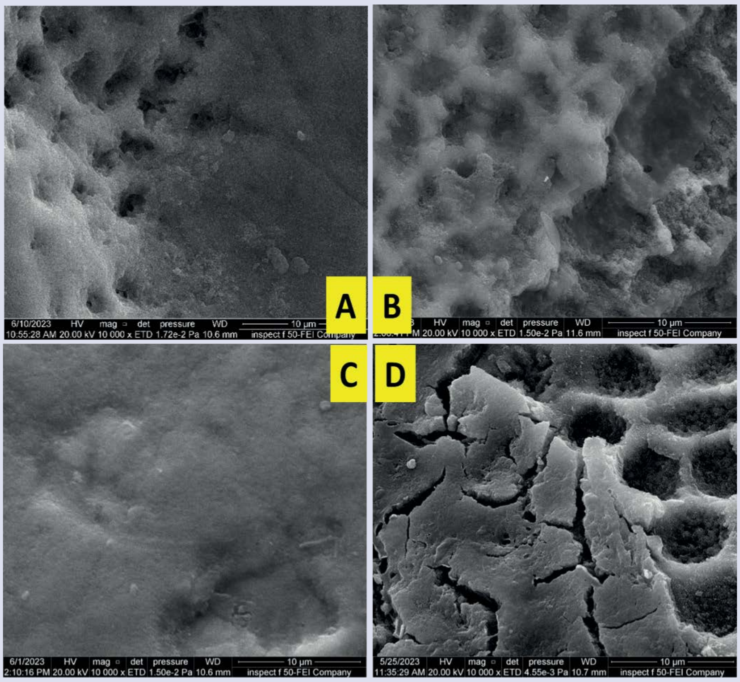


Figure 4. SEM images (10000x) of the enamel surface treated with (A) deionized water before bleaching (Control, TB1) showed morphological changes characterized by surface irregularities, porosities and depressions, with varying degrees of structural loss and erosion changes with depressed enamel prism cores can be noted in the enamel surface. (B, C, and D) were treated with Mouthrinse, Toothpaste, and Fluoride varnish, respectively. Then bleached with hydrogen peroxide 40%. Early stages of the honeycomb structure included slight prism core dissolution in the enamel surface. The primary structure is asymmetrical, with a slight dissolution of the prism cores. A surface disorganization is caused by the absence of the interprismatic form of the enamel's margins. Early stages of the honeycomb structure included slight prism core dissolution in the enamel surface due to demineralization. Also, we can see some protected areas that remain intact and contain cracks.

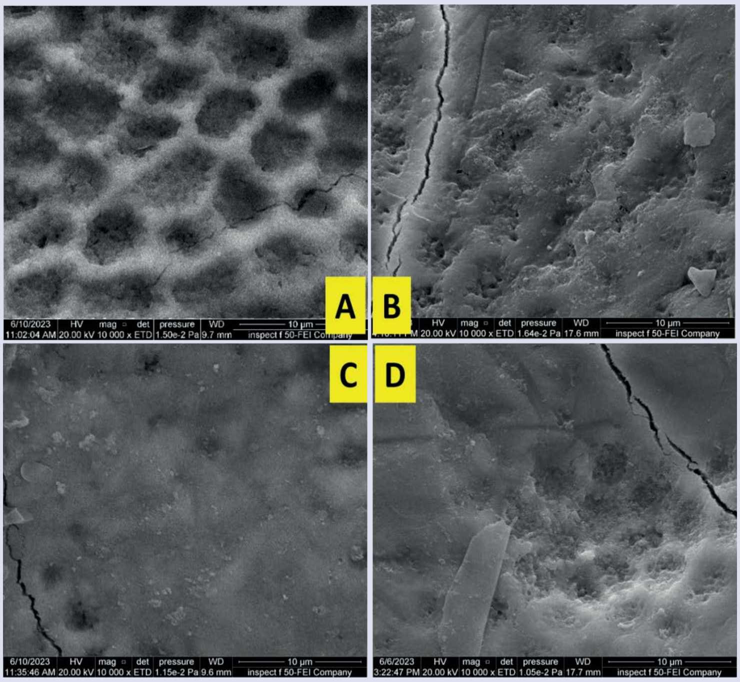


Figure 5. SEM images (10000x) of the enamel surface treated with **(A)** deionized water before and after bleaching (Control, TBT1) Showed morphological changes characterized by porosities, depressions, and surface irregularities with varying degrees of structural loss and erosion changes with depressed enamel prism cores can be noted in the enamel surface. **(B, C,** and **D)** were treated with Mouthrinse, Toothpaste, and Fluoride varnish, respectively, before and after bleaching with hydrogen peroxide 40%. Demonstrated a less pronounced erosion pattern with slight depressions in the enamel surface. Enamel-like crystal structure is shown. A homogeneous smoothed area between the interprismatic rods. Demonstrated a less pronounced erosion pattern with slight depressions in the enamel surface. Showed a smoother surface with erosion changes with depressed enamel prism cores and some evidence of irregularities.

images showed that interprismatic and intraprismatic substances had dissolved, creating micropores and a noticeable surface alteration that included irregularities and depressions. The same results were obtained compared to the sample treated with DDW before bleaching. The current study results assume no preventive effect of fluoridated mouthrinse, toothpaste, and varnish before in-office dental bleaching. These results were confirmed by surface roughness results that showed no statistically significant difference between group A and B results after bleaching. According to the literature, no data were available about the effect of fluoride when used before bleaching on the surface morphology of enamel.

The SEM images for the samples have been treated with mouthrinse, toothpaste, and fluoride varnish before and after in-office dental bleaching showed a smoother surface with less distinct erosion pattern and mild depressions in the enamel surface and slightly filled interprisms cavities with a subsequent reduction of their depth when compared to control sample -treated with DDW before and after bleaching- that showed more distinct erosion pattern, more depressions, and irregularities that indicate the effectiveness of these three remineralizing agents on the morphology of enamel surface, as showed in Figure 5.

The samples treated with fluoridated mouthrinse, toothpaste, and FV after bleaching only showed smoother surfaces with less distinct erosion patterns than those treated before and after bleaching. These results are likely related to fluoride deposition on the enamel surface of the samples treated before the bleaching process, which may prevent or minimize further remineralization after bleaching.[38] These results agree with Attin et al. (2007),[38] and Karlinsey et al.(2011),[39] they speculated that the fluoride uptake is higher in demineralized enamel than in sound tissue because the increased erosion caused by bleaching treatment facilitates fluoride penetration. Therefore, we assumed that the enamel surface that had received preventive protocol before bleaching showed more resistance to remineralization when treated after bleaching than the group treated after bleaching only. These results agree with our surface roughness findings as the means of surface roughness in group (B) showed fewer values from surface roughness means in group (A) after final treatment.

CONCLUSIONS

All three fluoridated oral health products used in the present study were beneficial as remineralizing agents after bleaching compared with the control group. But fluoride varnish was significantly better than mouthrinse and toothpaste in decreasing the surface roughness of enamel and treating the deleterious bleaching effect. The more beneficial effect was obtained when used only after bleaching.

REFERENCES

1. Alali J, Alanazi H, Alali O, Alzwayyid S. Teeth discoloration removal and management: a review. International Journal of Medicine in Developing Countries. 2020;4(7):1070-4. https://doi.org/10.24911/IJMDC.2.1.7.
2. Epple M, Meyer F, Enax J. A critical review of modern concepts for teeth whitening. Dentistry journal. 2019;7(3):79. https://doi.org/10.3390/dj7030079.
3. Noorsaeed AS, Lanqa S, Alshehri R, Linga S, Alzahrani RAJ, Ghamdi YKMA, et al. Causes and Management of Tooth Discoloration: A Review. Journal of Pharmaceutical Research International. 2021;33(60B):969-76. https://doi.org/10.9734/jpri/2021/v33i60b34701.
4. Prots H, Rozhko M, Paliichuk I, Nychyporchuk H, Prots I. Study of bone resorption as a risk factor in dental implantation in patients with generalized periodontitis. Georgian Medical News. 2023 Feb 1(335):73-8.
5. Almulayounis M, Al-Ali A. Effect of heat treatment duration and cooling conditions on tensile properties and hardness of selective-laser-melted cobalt-chromium alloy. Georgian Medical News. 2023 Apr 1(337):38-42.
6. AlOtaibi FL. Adverse effects of tooth bleaching: A review. International Journal of Oral Care and Research. 2019;7(2):53. https://doi.org/10.4103/INJO.INJO_22_19.
7. Al-Shaibani M, Al-Saffar M, Mahmood A. The impact of Aloe vera gel on remineralization of the tooth and its effect against Enterococcus faecalis: an in vitro study. Georgian Medical News. 2023 May 1(338):63-8.
8. Nam SH. Evaluation of the anti-caries effect of Lespedeza cuneata extract against Streptococcus mutans. Georgian Medical News. 2023 May 1(338):19-22.
9. Pajor K, Pajchel L, Kolmas J. Hydroxyapatite and fluorapatite in conservative dentistry and oral implantology—A review. Materials. 2019;12(17):2683. https://doi.org/10.3390/ma12172683.
10. Aljumaily E, Al-Khatib A. Hardness and elastic modulus assessment for two aligner materials before and after thermocycling: a comparative study. Georgian medical news. 2023 Jun(339):77-82.
11. Bilge K, Kılıç V. Effects of different remineralizing agents on color stability and surface characteristics of the teeth following vital bleaching. Microscopy Research and Technique. 2021;84(10):2206-18. https://doi.org/10.1002/jemt.23774.
12. Çakır A. The Effect of Different Cleaning Materials on the Bond Strength of Resin Composite to Primary Teeth Dentin Contaminated with Root Canal Sealer. Research Square. 2023. https://doi.org/10.21203/rs.3.rs-2591855/v1.
13. Bachiega-Silva B, Mayer-Santos E, Jurema ALB, Caneppele TMF, Brugnera-Junior A, de Freitas PM. In vitro effectiveness of different dental bleaching protocols using violet LED. Photodiagnosis and Photodynamic Therapy. 2023;42:103245. https://doi.org/10.1016/j.pdpdt.2022.103245.
14. Al-Ani SA, Al-Naimi R. Evaluation of the Effect of Casein Phosphopeptide–Amorphous Calcium Phosphate Mousse versus Natural Raw Fresh Milk on Enamel Surface Roughness After a pH Challenge. Al-Rafidain Dental Journal. 2020;20:183-94. https://doi.org/10.33899/rden.2020.127142.1032.
15. Son J-L, Shin Y-J, Jeong G-H, Choi S-J, Oh S, Bae J-M. Effect of fluoride varnishes on the surface hardness of bovine teeth under demineralization/remineralization cycling. The Journal of the Korean dental association. 2020;58(6):324-35.
16. Favaro JC, Ribeiro E, Guiraldo RD, Lopes MB, Aranha AM, Berger SB. Effect of mouth rinses on tooth enamel surface. Journal of Oral Science. 2020;62(1):103-6. https://doi.org/10.2334/josnusd.18-0370.
17. Majeed VO, Sarmamy HM, Mohammedamin RA. Evaluation of three remineralizing agents on surface roughness of enamel. Erbil Dental Journal (EDJ). 2022;5(1):84-92. https://doi.org/10.15218/edj.2022.11.
18. Taha NS, Qasim AA. Evaluation of the Additive Effects of Elmex Erosion Protection and Tooth Mousse Plus on Remineralization of Induced Eroded Enamel of Primary Teeth by specific Medicaments. Mosul, Iraq: University of Mosul, Dentistry College; 2021.
19. Soares LES, De Carvalho Filho ACB. Protective effect of fluoride varnish and fluoride gel on enamel erosion: roughness, SEM-EDS, and µ-EDXRF studies. Microscopy research and technique. 2015;78(3):240-8. https://doi.org/10.1002/jemt.22467.
20. Świetlicka I, Kuc D, Świetlicki M, Arczewska M, Muszyński S, Tomaszewska E, et al. Near-surface studies of the changes to the structure and mechanical properties of human enamel under the action of fluoride varnish containing CPP–ACP compound. Biomolecules. 2020;10(5):765. https://doi.org/10.3390/biom10050765.

21. Abdil-nafaa SA, Qasim AA. The Effect of Silver Diamine Fluoride and Fluoride Varnish on Roughness of Primary Teeth Enamel (An In Vitro Study). Al-Rafidain Dental Journal. 2020 Sep 1;20(2):296-307. http://dx.doi.org/10.33899/rden.2020.127479.1040.

22. Zaitsev AV, Ilenko-Lobach NV, Boychenko OM, Ilenko NM, Krutikova AD, Ivanitskyi IO, Bublii TD, Kotelevska NV. Integral method for assessing the efficiency of dental caries prevention. Georgian Medicalnews. 2023; 334(1): 133-136

23. Wijetunga CL, Otsuki M, Abdou A, Luong MN, Qi F, Tagami J. The effect of in-office bleaching materials with different pH on the surface topography of bovine enamel. Dental Materials Journal. 2021;40(6):1345-51. https://doi.org/10.4012/dmj.2021-010.

24. Faraoni-Romano JJ, Turssi CP, Serra MC. Concentration-dependent effect of bleaching agents on microhardness and roughness of enamel and dentin. American Journal of Dentistry. 2007;20(1):31-4.

25. Henn-Donassollo S, Fabris C, Gagiolla M, Kerber Í, Caetano V, Carboni V, et al. In situ and in vitro effects of two bleaching treatments on human enamel hardness. Brazilian Dental Journal. 2016;27:56-9. https://doi.org/10.1590/0103-6440201600385.

26. Ittatirut S, Matangkasombut O, Thanyasrisung P. In-office bleaching gel with 35% hydrogen peroxide enhanced biofilm formation of early colonizing streptococci on human enamel. Journal of dentistry. 2014;42(11):1480-6. https://doi.org/10.1016/j.jdent.2014.08.003.

27. Goyal K, Saha SG, Bhardwaj A, Saha MK, Bhapkar K, Paradkar S. A comparative evaluation of the effect of three different concentrations of in-office bleaching agents on microhardness and surface roughness of enamel–An in vitro study. Dental Research Journal. 2021;18.

28. Polydorou O, Scheitza S, Spraul M, Vach K, Hellwig E. The effect of long-term use of tooth bleaching products on the human enamel surface. Odontology. 2018;106(1):64-72. https://doi.org/10.1007/s10266-017-0308-3.

29. Nam SH, Ok SM, Kim GC. Tooth bleaching with low-temperature plasma lowers surface roughness and Streptococcus mutans adhesion. International Endodontic Journal. 2018;51(4):479-88. https://doi.org/10.1111/iej.12860.

30. Attia MR, Kamel MM. Changes in surface roughness of bleached enamel by using different remineralizing agents. Tanta Dental Journal. 2016;13(4):179-86. https://doi.org/10.4103/1687-8574.195707.

31. Bayrak S, Tuloglu N, Bicer H, Sen Tunc E. Effect of fluoride varnish containing CPP-ACP on preventing enamel erosion. Scanning. 2017(17):1 -7. https://doi.org/10.1155/2017/1897825.

32. Vieira A, Ruben J, Huysmans M. Effect of titanium tetrafluoride, amine fluoride and fluoride varnish on enamel erosion in vitro. Caries Research. 2005;39(5):371-9.

33. Lepri CP, Macedo RP, Marra VF, Paiva GR, de Castro DT, Martins VRG, et al. Influence of Remineralizing Agents on the Surface Roughness of Eroded Dental Enamel: in Vitro Study. Journal of Health Sciences. 2020;22(2):127-30. https://doi.org/10.17921/2447-8938.2020v22n2p127-130.

34. Vivek H, Prashant G, Geetha S, Chandramohan S, Imranulla M, Srinidhi P. Effect of mouthrinses containing olive oil, fluoride, and their combination on enamel erosion: an in vitro study. J Contemp Dent Pract. 2018;19(2):130-6. https://doi.org/10.5005/jp-journals-10024-2226.

35. Salama F, Abdelmegid F, Al-Sharhan M, Al-Mutairi F, Al-Nasrallah A. Effect of remineralizing agents on enamel surface roughness of primary teeth: An in– vitro study. EC Dental Science. 2020;19(2):1-12.

36. Zafar MS, Ahmed N. The effects of acid etching time on surface mechanical properties of dental hard tissues. Dental Materials Journal. 2015;34(3):315-20. https://doi.org/10.4012/dmj.2014-083.

37. Carvalho TS, Lussi A. Age-related morphological, histological and functional changes in teeth. Journal of oral rehabilitation. 2017;44(4):291-8. https://doi.org/10.1111/joor.12474.

38. Attin T, Betke H, Schippan F, Wiegand A. Potential of fluoridated carbamide peroxide gels to support post-bleaching enamel re-hardening. Journal of Dentistry. 2007;35(9):755-9. https://doi.org/10.1016/j.jdent.2007.06.005.

39. Karlinsey R, Mackey A, Walker T, Frederick K, Blanken D, Flaig S, et al. In vitro remineralization of human and bovine white-spot enamel lesions by NaF dentifrices: a pilot study. Journal of dentistry and oral hygiene. 2011;3(2):22.

40. Godinho M, de Ataide IdN, Lambor R, Fernandes M. Influence of two remineralizing agents on bleached enamel surface morphology and mineral composition–An In Vitro study. Indian Journal of Dental Research. 2022;33(2):188.

41. Fernandez-Ferrer L, Vicente-Ruiz M, Garcia-Sanz V, Montiel-Company JM, Paredes-Gallardo V, Almerich-Silla JM, et al. Enamel remineralization therapies for treating postorthodontic white-spot lesions: A systematic review. The Journal of the American Dental Association. 2018;149(9):778-86. e2. https://doi.org/10.1016/j.adaj.2018.05.010.

42. Slayton RL, Urquhart O, Araujo MW, Fontana M, Guzmán-Armstrong S, Nascimento MM, et al. Evidence-based clinical practice guideline on nonrestorative treatments for carious lesions: a report from the American Dental Association. The Journal of the American Dental Association. 2018;149(10):837-49. e19. https://doi.org/10.1016/j.adaj.2018.07.002.

43. Martin JMH, Janaína Bertoncelo de Almeida, Edvaldo Antonio Ribeiro Rosa, Vladja Torno, Rodrigo Nunes Rached, Rui Fernando Mazur. Effect of fluoride therapies on the surface roughness of human enamel exposed to bleaching agents. Quintessence Int. 2010;41:71-8.

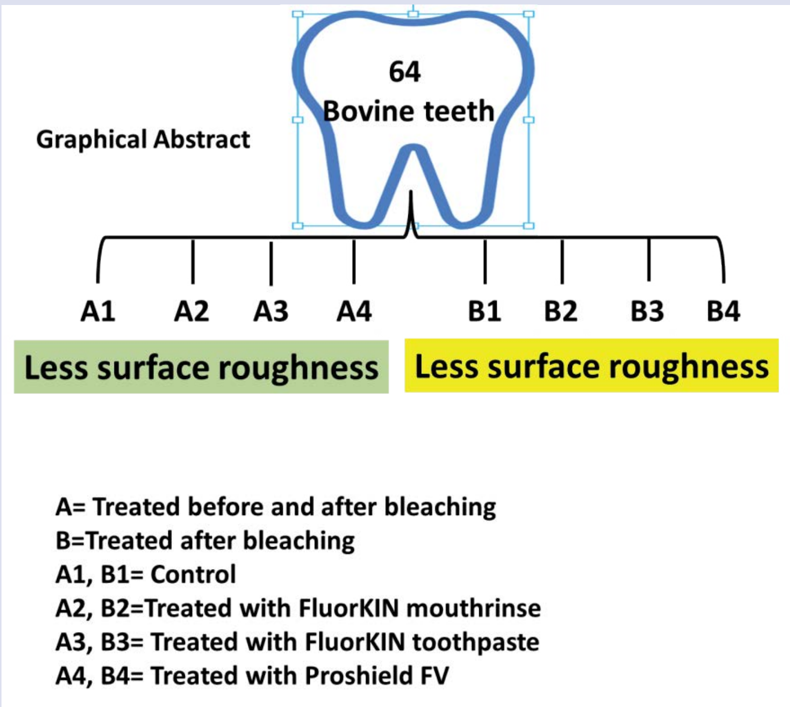
44. Mazzoleni S, Gargani A, Parcianello RG, Pezzato L, Bertolini R, Zuccon A, et al. Protection against Dental Erosion and the Remineralization Capacity of Non-Fluoride Toothpaste, Fluoride Toothpaste and Fluoride Varnish. Applied Sciences. 2023;13(3):1849. https://doi.org/10.3390/app13031849.

45. Ergucu Z, Yoruk I, Erdoğan A, Boyacıoğlu H, Hill R, Baysan A. The Use of Toothpastes Containing Different Formulations of Fluoride and Bioglass on Bleached Enamel. Materials. 2023;16(4):1368. https://doi.org/10.3390/ma16041368.

46. El Moshy S, Abbass MM, El-Motayam AM. Biomimetic remineralization of acid etched enamel using agarose hydrogel model. F1000Research. 2018;7(1):1476. https://doi.org/10.12688/f1000research.16050.1.

47. Dong J, Zhu Y, Feng H. The Anti-Cariogenic Effect of fluoride iontophoresis on sound enamel under different working conditions: An in vitro study. Materials Research Express. 2023;10(3):036301. https://doi.org/10.1088/2053-1591/acbd17.

GRAPHICAL ABSTRACT



Cite this article: Alsabeel MH, Qasim AA. Impact of Fluoridated Dental Products on Surface Roughness and Morphology of Bleached Tooth Enamel: An In Vitro Study. Pharmacogn J. 2024;16(1): 217-225.