Roughness of Human Enamel Surface Submitted to Different Prophylaxis Methods

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The purpose of this in vitro study was to evaluate alterations in the surface roughness and micromorphology of human enamel submitted to three prophylaxis methods. Sixty-nine caries-free molars with exposed labial surfaces were divided into three groups. Group I was treated with a rotary instrument set at a low speed, rubber cup and a mixture of water and pumice; group II with a rotary instrument set at a low speed, rubber cup and prophylaxis paste Herjos-F (Vigodent S/A Indústria e Comércio, Rio de Janeiro, Brazil); and group III with sodium bicarbonate spray Profi II Ceramic (Dabi Atlante Indústrias Médico Odontológicas Ltda, Ribeirão Preto, Brazil). All procedures were performed by the same operator for 10 s, and samples were rinsed and stored in distilled water. Pre and post-treatment surface evaluation was completed using a surface profilometer (Perthometer S8P, Marh, Perthen, Germany) in 54 samples. In addition, the other samples were coated with gold and examined in a scanning electron microscope (SEM). The results of this study were statistically analyzed with the paired t-test (Student), the Kruskal-Wallis test and the Dunn (5%) test. The sodium bicarbonate spray led to significantly rougher surfaces than the pumice paste. The use of prophylaxis paste showed no statistically significant difference when compared with the other methods. Based on SEM analysis, the sodium bicarbonate spray presented an irregular surface with granular material and erosions. Based on this study, it can be concluded that there was an increased enamel surface roughness when teeth were treated with sodium bicarbonate spray when compared with teeth treated with pumice paste.

Keywords: *dental enamel; dental prophylaxis; jet abrasive system; enamel roughness; scanning electron microscope.*

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INTRODUCTION

The use of dental prophylaxis to remove the salivary pellicle, plaque, and/or surface debris is a well-known clinical preventive procedure.[1-3] Although materials and techniques available in restorative dentistry have been significantly improved in the last years, there is still consensus that prevention plays a key role in oral health.[1,2,4]

The prophylaxis methods in dentistry were previously restricted to the application of abrasives with the use of rubber cups, brushes or dental tapes, as well as ultrasonic and manual scaling.[1,5] Although an air polishing system consisting of sodium bicarbonate, water and air jet was introduced as a prophylactic instrument in the eighties,[5] little is known regarding the effect of these prophylactic methods on the tooth surface.[3,6-8]

Eventhough enamel shows a smooth surface clinically, it actually presents on its surface several structures that are detected only microscopically. The perikymata consists of shallow furrows resulting from the extension of the striae of Retzius from the dentinoenamel junction to the outer surface of enamel.[9] The perikymata furrows run in circumferentially horizontal lines across the face of the crown, especially at the cervical third, rendering to the enamel surface a wrinkled appearance where organic debris might accumulate.[2-4] Both the rubber cup and the sodium bicarbonate jet may alter the polished surface of the dental enamel, either causing scratches or leaving rough surfaces that facilitate a faster accumulation of biofilm, stains and/or products of degradation.[5,10,11] However, some authors claim that there are no morphological alterations with these methods[12] or that these alterations are minimal, being clinically safe and efficient.[13–16] The effects of prophylaxis on enamel may have an impact in pediatric dentistry since this procedure is routinely performed in children who require preventive treatment such as fluoride and sealant application.[2,12]

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The purpose of this study was to quantify and compare the difference in enamel surface roughness using a surface profilometer following treatment with a sodium bicarbonate jet, a rubber cup and pumice slurry, and a prophylactic paste. In addition, representative samples were evaluated before and after cleansing by scanning electron microscopy.

MATERIALS AND METHODS

Sixty-nine human third molars with healthy buccal surfaces and absence of cracks, calculus or stains were supplied by the Human Tooth Bank of the School of Dentistry, University of São Paulo, Brazil and stored in distilled water at ambient temperature.[10] This study was approved by the Ethical Committee of the School of Dentistry, UNESP, Brazil (Protocol # 090/2005-PH/CEP-UNESP).

The teeth were equally divided into three groups. Teeth were embedded in acrylic resin while maintaining the buccal surfaces exposed. Each group received a different prophylactic treatment as follows:

In Group I, prophylaxis of the buccal surface was performed with a low speed micro-motor (Kavo do Brasil Indústria e Comércio Ltda., Joinville, Brazil), a rubber cup (Viking, KG Sorensen, Barueri, Brazil), and a mixture of pumice (S.S.White, Juiz de Fora, Brazil), and distilled water. The professional was trained to allow some of the product to remain on the tooth surface at the end of the procedure.[16] The proportion of the mixture consisted of 60 g of pumice to 50 ml of distilled water, mixed uninterruptedly for 10 s, with circular movements over the entire buccal surface, under light pressure, restricted to the micro-motor weight (150 g) and at a speed set to 5000 rpm.

In Group II, the prophylaxis was performed with prophylaxis paste Herjos-F (Vigodent S/A Indústria e Comércio, Rio de Janeiro, Brazil) using the same type of movement, pressure, speed and duration as in Group I. This paste contains water, lauril sulfate, calcium carbonate, pumice and artificial flavor.

In Group III, sodium bicarbonate, water and air jet were applied with the Profi II Ceramic (Dabi Atlante Indústrias Médico Odontológicas Ltda, Ribeirão Preto, Brazil). The tip of the jet was placed at a distance of 5 mm,[5] forming an angle of 90º with the tooth surface,[7] following the manufacturer's instructions. The procedure was performed uninterruptedly for 10 s, with circular movements[15] over the entire buccal surface. A single professional performed all the procedures, such that the differences in micro-motor pressure intensity and movement would be minimized. The samples were then jet washed for 10 s with water and air-dried for 5 s.

For the assessment of enamel surface roughness, eighteen teeth from each group were evaluated before and after treatment using a surface-analyzing instrument, the Perthomether (S 8 P, Marh, Perthen, Germany) with an optic micropalpator laser (T9 Focodyn) from the Laboratory of Optic Surface Measurement of the Institute for Advanced Studies (CTA, São José dos Campos - Brazil). Three readings were performed for each sample to obtain the mean value.[3] The reading was performed in the middle of the buccal surface, perpendicular to the long axis of the tooth with a linear displacement of 1.2 mm. The values obtained were the mean roughness (Ra), measured in µm using the mean of three readings before and after treatment per sample for each group. The data obtained were organized in tables and submitted to the t-Student equated pairs, the Kruskall-Wallis and the Dunn statistical analyses.

In addition, the enamel surfaces of the 5 remaining samples from each group were processed for scanning electron microscopy. The samples were dehydrated through an increasing ethanol series and air-dried. Specimens were mounted on aluminum stubs with the treated surfaces facing up using colloidal silver adhesive and sputter-coated with gold in a Bal-Tec SDC-050 apparatus, before examination under a scanning electron microscope (Jeol 6100, Tokyo, Japan) operating to 10-15 kV.

Table 1. Ra profilometer readings (in µm). Mean (+Standard deviation)

	Before	After	Alteration
GROUP I (Pumice paste)	2.30 +0.87	2.07 + 0.60	-0.22 + 0.98
GROUP II (Prophylactic paste)	2.19 + 0.78	2.16 + 0.74	0.03 + 1.05
GROUP III (Sodium bicarbonate)	1.98 + 0.61	2.57 + 0.92	0.59 + 1.07

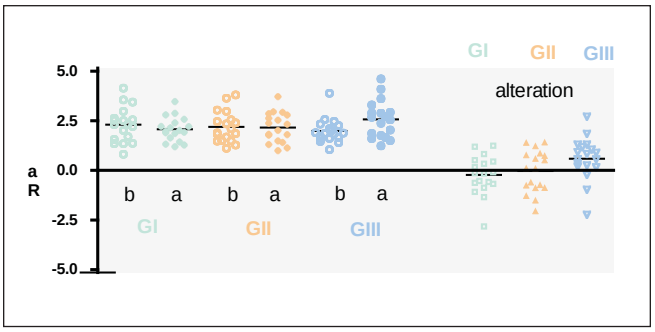

Figure 1. Graphical representation of Ra showing the roughness before (b) and after (a) treatment per group and the effect (alteration) on the enamel surface.

RESULTS

Results of the average roughness (Ra) of the enamel surface of the samples, before and after treatment, are summarized in Table 1 and graphically illustrated in Figure 1.

The Kruskall-Wallis test and the Dunn multiple comparison test were applied ($p<0.05$), showing that the distribution of the values obtained in Groups G I and G III differ statistically. G III presented greater alteration of roughness, while G I showed the best experimental condition, and G II displayed an intermediate behavior when compared with the other groups. Thus, the bicarbonate jet group differed from the pumice paste group, while the prophylactic paste group did not differ from the pumice paste or the bicarbonate jet groups.

The SEM examination revealed an aspect of the enamel surface that confirmed the roughness assessment. While samples from the control group exhibited an enamel surface with perikymata and occasional small defects caused by

Figure 2. Scanning electron micrograph showing a specimen from the control group (without treatment). Note the characteristic wave-like appearance of the intact enamel surface, with characteristic depressions (asterisks). 2200x.

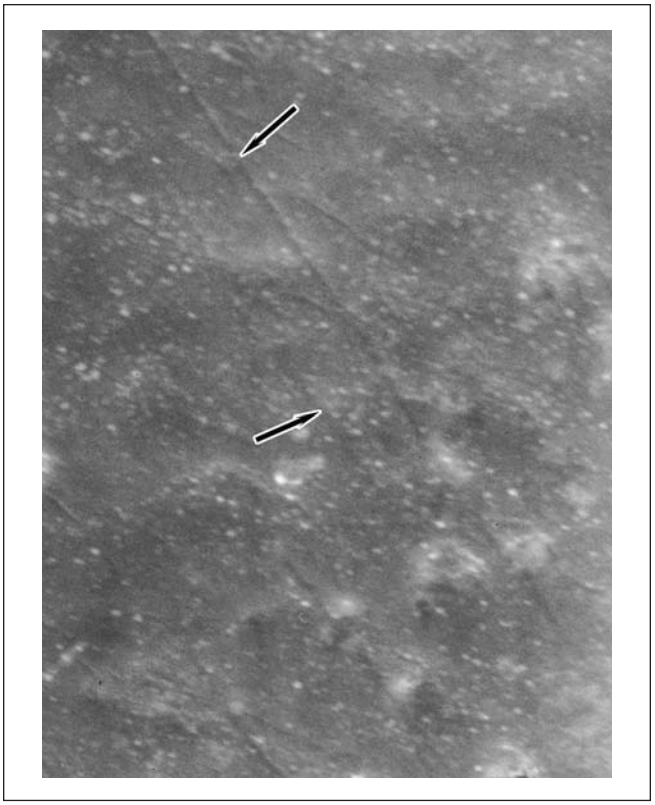

Figure 3. Scanning electron micrograph showing a specimen from Group I (pumice paste). Note the presence of scratches (arrows), however, this surface is smoother than that of the control group. 2200x.

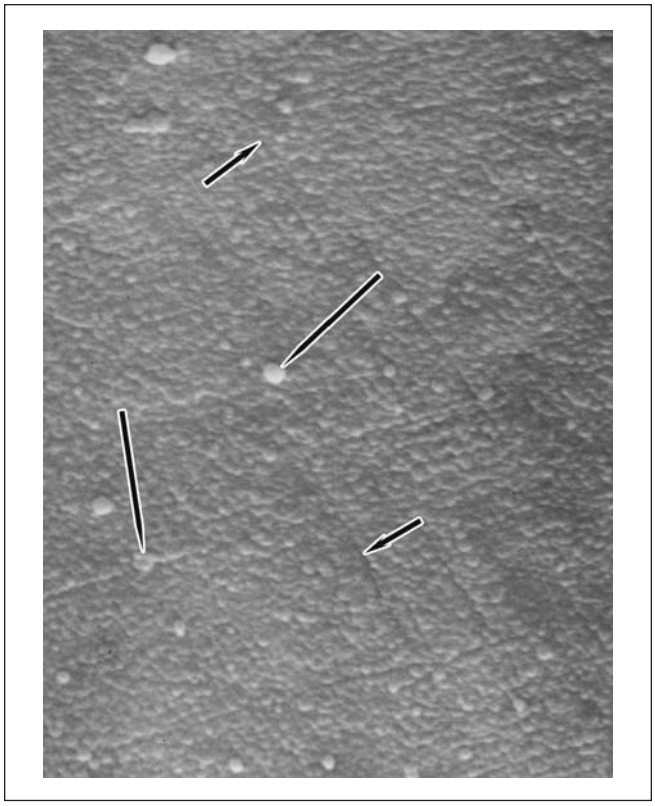

Figure 4. Scanning electron micrograph showing a specimen from Group II (prophylactic paste). Numerous lines/scratches (arrows) and granules (long arrows) on the enamel surface. 2200x.

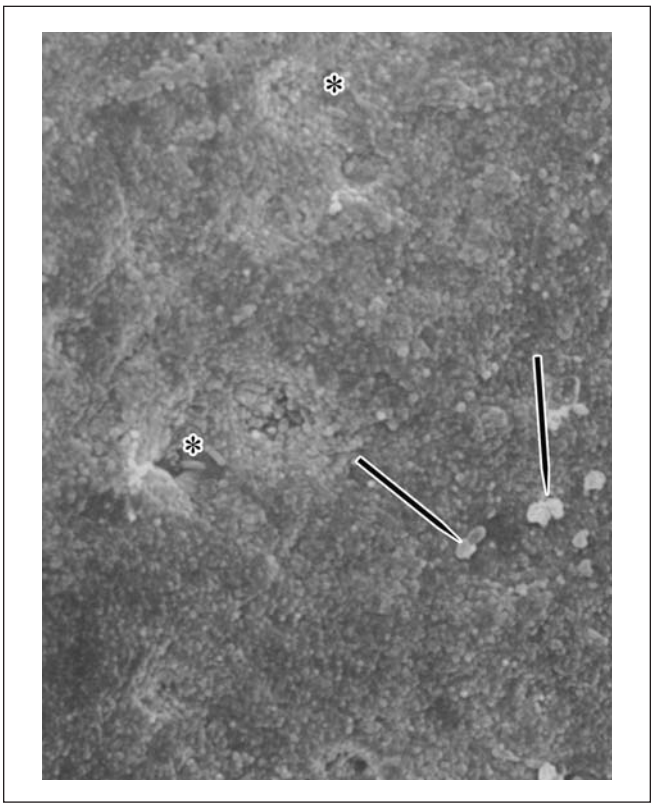

Figure 5. Scanning electron micrograph showing a specimen from Group III (sodium bicarbonate jet). Variable diameter granules (long arrows) and numerous depressions (asterisks) yield a rougher enamel aspect than in previous groups. 2200x.

deposition of minerals from the oral environment (Figure 2), all the experimental groups showed several alterations in the surface roughness of the enamel. In Group I (pumice paste), scratches were observed on the enamel surface, though without presence of granules (Figure 3). Samples from Group II (prophylactic paste) displayed numerous lines and scratches, as well as small granules on the enamel surface. At higher magnifications, the granular appearance consisted of variable diameter granules and the presence of scratches (Figure 4). When sodium bicarbonate jet was applied on the enamel surfaces (Group III), lower magnifications showed a very irregular and rough surface with granules and depressions spread throughout the enamel surface (Figure 5).

DISCUSSION

The results of the present study revealed alteration of the enamel surface with all the prophylactic methods applied.[5,14–16] This outcome was assessed through an evaluation of the surface roughness and a scanning electron microscopy examination.[5,11]

The roughness of the enamel surface did not increase with the Herjos-F prophylactic paste. Although the values after this procedure were slightly higher than those recorded prior to prophylaxis, they were statistically similar, fact confirmed by the micromorphological analysis where no discernible differences were noted, and in agreement with previous studies.[7,8,10,12,14,15,17,18]

As expected, the roughness of the enamel surface did not increase with pumice paste.[16] In fact, no statistical difference was observed between the roughness value of untreated teeth and that of those polished with pumice paste, confirmed when these enamel surfaces were examined by scanning electron microscopy, even at higher magnifications. A study focusing on enamel surfaces, where pumice paste was applied prior to restoration with dental adhesives, agreed with our findings.[5,16] Several scratches were noticed on the enamel surface treated with pumice paste,[11] because of its considerable abrasiveness despite its well-known cleaning efficacy.[19-21]

A more evident alteration on the enamel surface was produced by the bicarbonate jet, increasing surface roughness[5] and creating depressions.[22,23] The difference between the effects of the bicarbonate jet and the pumice paste was statistically significant and micromorphologically evident. In addition, several variable size granular particles were noticed on the enamel surface treated with the bicarbonate jet, suggesting that the washing time should be increased when this procedure is applied in the clinic. Hosoya and Johnston[11] suggested that these granular particles are residues of organic film, particles of abraded enamel, and abrasive particles of sodium bicarbonate itself. Although it was not the aim of the present study, it has been shown that roughness after the application of the jet abrasive was greater when some amounts of biofilm were present on the surface before treatment.[22,24] Whether this is true or not, the present findings suggest that prophylaxis with bicarbonate jet might leave highly rough enamel surfaces impairing the maintenance of adequate oral hygiene by the patient.

Although *in vitro* research should not be extrapolated to the clinic, it is likely that the prophylactic methods tested are clinically safe and the alterations caused by the methods tested herein do not contra-indicate these procedures, as no serious or irreversible damage to the enamel structure was observed. Nevertheless, it is recommended that clinicians use caution when using the sodium bicarbonate jet in routine prophylactic procedures.

CONCLUSIONS

In accordance with the analysis of surface roughness and micromorphology of enamel submitted to three prophylactic methods, it was concluded that:

- The use of pumice paste caused a slight reduction in roughness, significant only when compared with the roughness produced by the bicarbonate jet.
- The bicarbonate jet prophylaxis significantly increased enamel surface roughness when compared with the pumice paste prophylaxis.
- The use of prophylactic paste showed no statistically significant difference when compared with the other two methods.

All the prophylactic methods used caused alterations in enamel surfaces detected by the micromorphological examination.

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