Enamel morphology after microabrasion with experimental compounds

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Abstract

Background: Enamel microabrasion is an esthetic treatment for removing superficial stains or defects of enamel. **Aim:** This study evaluated the roughness after enamel microabrasion using experimental microabrasive systems. **Materials and Methods:** One hundred and ten samples (5 × 5 mm) were obtained from bovine incisors and divided into 11 groups (n = 10) in accordance with the treatment: Microabrasion using 6.6% hydrochloric acid (HCl) or 35% phosphoric acid (H_3PO_4) associated with aluminum oxide (AlO_3) or pumice (Pum) with active application (using rubber cup coupled with a micro-motor of low rotation) or passive application (just placing the mixture on the enamel surface); just the use of acids in a passive application (negative control), and a group without treatment (positive control). Roughness analysis was performed before and after treatments. The statistical analysis used analysis of variance (PROC MIXED), Tukey-Kramer and Dunnet tests (P < 0.05). Representative specimens were evaluated using scanning electron microscopy (SEM). **Results:** There was no significant difference between the acids used (P = 0.0510) and the applications (P = 0.8989). All of the treated groups were statistically different from the positive control. When using passive application, the use of HCl + AlO_3 resulted in higher roughness when compared with HCl + Pum. Additionally, this treatment was statistically different from the passive application of H_3PO_4 (negative control) (P < 0.05). However, SEM analysis showed that the treatment with AlO_3 resulted in an enamel surface with a more polished aspect when compared with Pum. **Conclusion:** AlO_3 may be a suitable particle for use in microabrasive systems.

Keywords: Enamel, microabrasion, roughness

Introduction

Enamel microabrasion is a procedure used for removing a superficial layer of enamel that has some alteration of color and/or texture.[1] This procedure is performed utilizing an association of an erosive agent (phosphoric acid (H_3PO_4) or hydrochloric acid (HCl)) and an abrasive agent (pumice (Pum) or silica particles).[2-4] With the technique, a sub layer of enamel with normal characteristics is exposed. As the enamel wear is minimal, microabrasion is considered a safe and conservative procedure, when correctly prescribed.[4-7]

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Recently, scientific studies have been performed to improve microabrasion and to know its effects on enamel.[8-12] Initially, the acid used for microabrasion was 18% HCl; today, it is recognized that this concentration is considered erosive and toxic. Currently, the same acid is employed at a lower concentration and containing silica in commercial formulations.[5-7] Another combination used for the microabrasion technique is 35% H_3PO_4 coupled with Pum, in equal parts.[13] This mixture is advantageous because of its low cost and accessibility. However, it is subject to variations when the operator mixes the compounds.[5,8]

The effects of microabrasion on enamel are related to the compounds, both erosive and abrasive, and to the mechanical pressure exerted when using microabrasion cups in slow-speed hand pieces.[14-16] The common effects include increased roughness values, which are reestablished by saliva over a period between 7 and 15 days.[8,9,11] In relation to the morphology, microscopic evaluations have shown that microabrasion causes alterations to the enamel surface, similar to the conditioning patterns caused by H_3PO_4, to include exposure of the interprismatic spaces.[17] Therefore, the enamel characteristics resulting from the technique are most likely related to the acid concentration and pH, in addition to the time and pressure of instrumentation and application.[14,17] The abrasive is also relevant, as Pum is believed to present excessive abrasiveness and deep erosion when compared to other abrasive systems.[18]

The aim of this study was to evaluate the effect of the acids (hydrochloric and phosphoric) in conjunction with different experimental abrasive mixtures on enamel morphology by means of roughness analysis and scanning electron microscopy (SEM).

Materials and Methods

Preparation of specimens

Bovine incisor teeth were selected and stored in a formaldehyde solution for at least 1-month. After the coronary portion was separated using a double-faced diamond disk (KG Sorensen, Ind. Com. Ltda.; Barueri, SP, Brazil), 110 enamel/dentin slabs (5 × 5 × 3 mm) were obtained using a precision saw (Isomet 1000; Buehler, Illinois, USA) and a high-concentration diamond disk (4" ×012 × ½, Buehler, Illinois, USA). The enamel surface of the blocks was flattened in a circular polishing machine (Aropol E, Arotec, Cotia; São Paulo, SP, Brazil), under water cooling, using the following: Silicon carbide papers of decreasing granulation (#300, #600 and #1200), felts, and diamond pastes of 1, 1/2 and 1/4 µm granulation greased with a specific oil (Arotec, Cotia; SP, Brazil). Between the polishing steps and after the final polishing, all slabs were cleaned for 15 min in an ultrasonic device (Marconi, Piracicaba, SP, Brazil) that contained distilled water.

Surface treatment

The following ingredients were used to fabricate the experimental microabrasive products:

- 6.6% hydrochloric acid (HCl – Drogral-Piracicaba, São Paulo/Brazil)
- 35% H_3PO_4 (H_3PO_4 – Ultradent Products – Utah, USA)
- Aluminum oxide (AlO_3-NMartis – Colombo, Paraná/Brazil)
- Pumice (SS White LTDA, Rio de Janeiro, RJ/Brazil).

The specimens were randomly divided into 11 groups based on the acid and abrasive used and the application technique [Table 1].

All of the microabrasive products were formed using equal parts of each component as measured using a dosage spoon (0.240 g). The specific treatments were placed on the enamel surface with a syringe until the sample was covered; the amount required was 0.0200 g for the groups treated with acid and abrasive and 0.0150 g for the groups treated with acid only. The application of the acids in a passive form was performed to clearly identify the effects of the experimental mixtures on enamel, with these serving as negative controls. All of the surface treatments were performed with 10 applications for 10 s each. After each application, the enamel surface was rinsed and dried for 10 s using a dental sprayer and compressed air, respectively. The control group (positive) did not receive treatment.

Enamel roughness analysis

The enamel roughness regression analysis (Ra) was analyzed, using a profilometer roughness tester (Mitutoyo Surfitest 211, São Paulo, SP, Brazil) before and after the microabrasive treatment. A diamond stylus was used to measure the surface roughness, using a cut-off of 0.25 mm and speed of 0.5 mm/s, under a constant load (5 N). The numeric values representing the roughness profile were computed and represented as Ra. Three readings were made in three different directions on the enamel surface, with the mean values of the measuring points calculated.

Scanning electron microscopy

For SEM analysis (JEOL.JSM 5600 LV, Tokyo, Japan), representative specimens from each group were placed on an acrylic stub under aluminum tape (3M Adhesives Ltd., St. Paul, MN, USA) and were sputter coated (Balzers – SCD 050 sputter coter, Germany) with a thin layer of gold, equivalent to 10^{-6} mm, and under vacuum, to increase the surface reflectance. Photomicrographs (×4000) of representative areas of the specimens were obtained.

Statistical analysis

The data obtained were submitted to statistical analysis using analysis of variance (PROC MIXED) for repeated measures, followed by Tukey's and Dunnett's tests. The significance level was 5%.

Results

Table 2 shows that all of the experimental groups presented an increase in the roughness values, with statistically significant differences when comparing the initial and final values. Additionally, there were no statistical differences between the acids used ($P = 0.0510$) or the application forms ($P = 0.8989$) with regards to roughness. However, the association between HCl and AlO_3 presented the highest mean value of surface roughness when applied in the passive form, which was statistically different from the association of Pum with the same acid and application. The comparison with negative controls showed a difference

Table 1: Groups of study

Acid	Abrasive	Application technique
6.6% HCl	AlO_3	Active
		Passive
	Pumice	Active
		Passive
35% H_3PO_4	AlO_3	Active
		Passive
	Pumice	Active
		Passive
HCl	-	Passive
H_3PO_4	-	Passive
Control	-	-

HCl: Hydrochloric acid; H_3PO_4: Phosphoric acid; AlO_3: Aluminum oxide

Table 2: Enamel roughness in micrometers, means (SD) in the analysis before and after treatments

Acid	Abrasive	Application	Analysis	
			Initial	Final
HCl	AlO_3	Active	0.28 (0.01) B	0.49 (0.01) A^{d}
		Passive	0.15 (0.04) B	0.57 (0.12) A$^{\$,d,\#}$
	Pumice	Active	0.27 (0.05) B	0.47 (0.09) A^{d}
		Passive	0.25 (0.08) B	0.41 (0.06) A^{d}
H_3PO_4	AlO_3	Active	0.22 (0.11) B	0.40 (0.11) A^{d}
		Passive	0.19 (0.05) B	0.49 (0.07) A^{d}
	Pumice	Active	0.15 (0.09) B	0.37 (0.08) A^{d}
		Passive	0.26 (0.06) B	0.46 (0.07) A^{d}
HCl	-	Passive	0.28 (0.11) B	0.47 (0.17) A
H_3PO_4	-	Passive	0.22 (0.08) B	0.43 (0.07) A
Control			0.20 (0.01) A	0.16 (0.02) A$^{\&,\#}$

Different letters simply statistically significant differences, in rows ($P \leq 0.05$). $^{\$}$Differ from Pum used in the same acid, application and time ($P \leq 0.05$); There was not difference between the acids (P=0.0510) and between the application forms (P=0.8989). $^{\&}$Differ from HCl in the same time ($P \leq 0.05$)/$^{\#}$Differ from H_3PO_4 in the same time ($P \leq 0.05$); ^{d}Differ from control group ($P \leq 0.05$). SD: Standard deviation; HCl: Hydrochloric acid; H_3PO_4: Phosphoric acid; AlO3: Aluminum oxide

between the association of HCl with AlO_3 (passive application) and H_3PO_4, showing the erosive power of the HCl and the inability of the AlO_3 to reduce the effects of HCl on enamel roughness. The control group (positive control) was statistically different from all of the experimental groups and the negative controls, proving the erosive action of the acids and the microabrasive mixtures on enamel roughness.

Scanning electron microscopy images showed different conditioning patterns for the different acids and microabrasive systems. Treatment with HCl in the microabrasive mixtures [Figure 1] did not present any specific conditioning pattern, with no evidence of the prism core (type I) or the prism periphery (type II), as found with the H_3PO_4 treatment, in which the type I [Figure 2] conditioning pattern was found. The combination of HCl with abrasive particles and active application [Figure 1a and c] resulted in a polished enamel surface, most noticeably with the association of HCl and AlO_3 [Figure 1a]. With the passive application [Figure 1b and d], HCl^{+} abrasives showed a tendency to exhibiting the demineralization characteristics as seen in Figure 3a. Treatment with H_3PO_4 and Pum [Figure 2c and d] presented the conditioning pattern type I, which was also found with the treatment using just H_3PO_4 [Figure 3b]. The association between H_3PO_4 and AlO_3 tended to present enamel conditioning without complete exposition of the prism cores, showing the action of this abrasive in reducing the erosive powder of the acid. Regarding the treatments with just the acids [Figure 3], H_3PO_4 exhibited more demineralization than HCl.

Discussion

Enamel microabrasion has become accepted as a conservative, nonrestorative method of improving the appearance of teeth with superficial defects or alteration of color.[2,3,5,6,19] The technique is based on mild acid etching in combination with a rotary application of an abrasive medium.[16] Studies have suggested the existence of an "abrosion effect," whereby the erosive action of the acid coupled with an abrasive action to compact the mineralized tissue within the organic area. Through this process, the outer layer of prism-rich enamel is replaced with a densely compacted and prism-free region.[5-7,20,21] However, the enamel surface after treatment presents with alterations in roughness and microhardness.[8-11] The results on this present study demonstrated that all experimental microabrasive systems and acids caused an increase in superficial enamel roughness, as each experimental agent showed specific enamel conditioning when observed under SEM.

According to [Table 2], the roughness means increased after the microabrasion treatments (active application), and after the passive application of the microabrasive systems or acids, as related in other studies.[8,9,11] These results in all experimental groups, including the passive application of the acids, may be explained due to the erosive action of the acids used.[17,22] This action is responsible for enamel demineralization, as visualized in the SEM images. Although the microscopy analysis shows different conditioning patterns between the acids used, in which H_3PO_4 presents major evidence of demineralization with marked exposition of the prism cores,[23] the absence of statistical differences for roughness in relation to the acids used (P = 0.0510) did not allow for defining which acid (35% H_3PO_4 or 6.6% HCl) had the greater erosive action on enamel.

In relation to the abrasive compounds used, AlO_3 in combination with both acids [Figures 1 and 2] resulted in a more polished and glossy enamel surface that was more likely to be similar to the surface found in the control group [Figure 4] when observed under SEM. This polished surface should be a result of the "abrosion effect," as related by Croll (1997).[20] This effect can be explained due to the effect of the polish conferred by the AlO_3, which has a constant grain size (60 μ) and is commonly used for finishing and polishing restorative materials and enamel surfaces.[24]

As part of the microabrasion technique, it is important to perform a final polish using abrasive materials (felt disks and diamond paste) to finalize the esthetic appearance and minimize the surface roughness of the enamel,[7,9,11] since greater surface roughness leads to greater plaque accumulation.[25] Therefore, the technique using AlO_3 would obtain a polished enamel surface, which might reduce the clinical time for the technique, as it could eliminate the

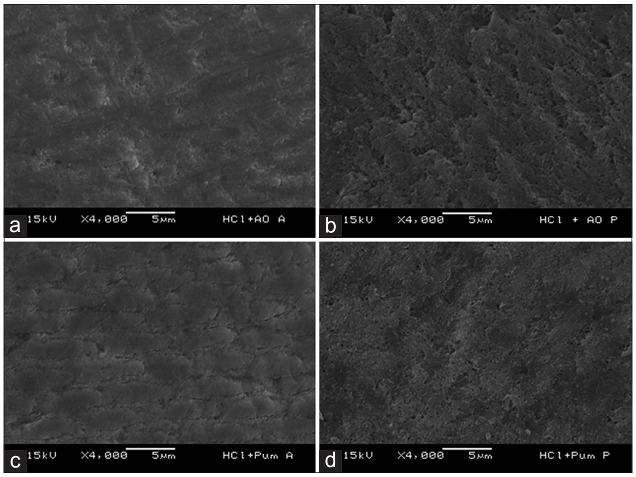

Figure 1: Scanning electron microscopy photomicrography for the groups treated with hydrochloric acid (HCl) in the microabrasive system treatment using the association between HCl and aluminum oxide (a and b) or Pumice (c and d) with passive active (a and c) or passive (b and d) modes of application

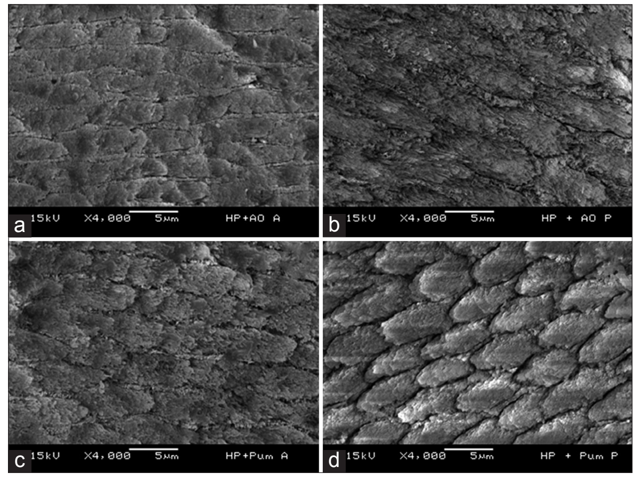

Figure 2: Scanning electron microscopy photomicrography for the groups treated with phosphoric acid (H3PO4) in the microabrasive system treatment using the association between H3PO4 and aluminum oxide (a and b) or Pumice (c and d) with passive active (a and c) or passive (b and d) modes of application

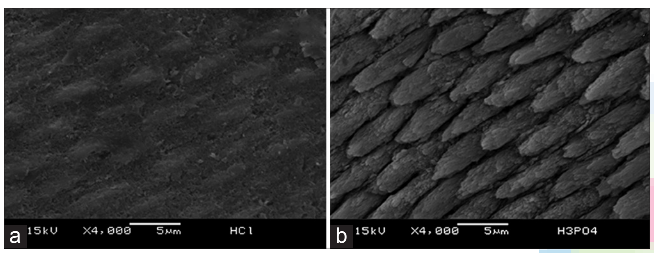

Figure 3: Scanning electron microscopy photomicrography for the groups treated with just the placement of the acids treatment hydrochloric acid (a) and phosphoric acid (b)

polishing stage. While the enamel roughness increased when using this abrasive, the literature is emphatic in demonstrating the remineralization effect of saliva in minimizing the roughness and microhardness alterations of enamel after microabrasion.[8,9,11,26]

With both application modes, the SEM analysis showed that HCl, in a low concentration, combined with AlO_3 or Pum [Figure 1], resulted in an enamel surface that was less eroded when compared to surfaces treated with H_3PO_4. This may be explained due to the conditioning pattern observed with this acid, in which there was no marked exposition of the core or periphery of the prisms. Even though there were no statistically significant differences between the application forms of the microabrasives ($P = 0.8989$), the active application using special rubber cups in a slow-speed hand piece is well defined in the literature as being important for the microabrasion technique.[14,15,27]

With regards to the passive application of the microabrasive mixtures containing AlO_3, as the roughness analysis for its use with HCl showed higher and statistically significant

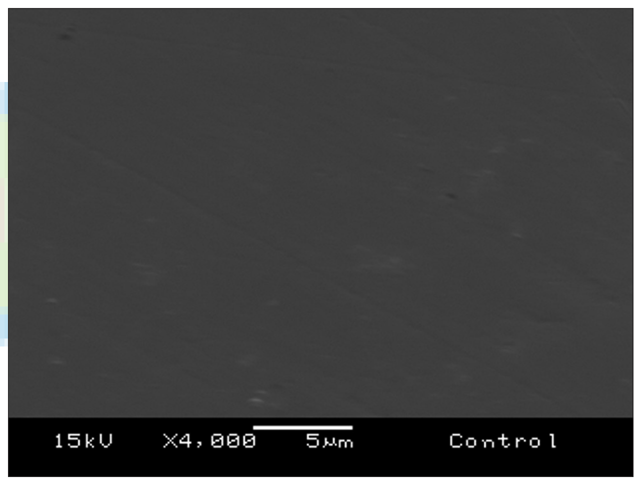

Figure 4: Scanning electron microscopy photomicrography for the control group. Control group without observation of any conditioning pattern

roughness means in relation to the Pum for the same acid and application form ($P < 0.05$), it can be suggested that the Pum, as an abrasive, may neutralize or reduce the erosive action of the acids better when compared to the AlO_3. However, regarding the SEM analysis, less invasive enamel surface conditioning was noted with the use of HCl when compared to the use of H_3PO_4, even considering that the AlO_3 may present a neutralizing action. Even so, the association between HCl and AlO_3 may be suitable for use, considering that the enamel roughness is corrected over time with exposure to saliva, as shown in *in vitro*[9,11] or *in situ*[8,26] studies. The improvement in roughness due to saliva is due to it containing a buffering capacity that may be improved by specific remineralizing agents, such as fluoride.[28,29]

When considering the results obtained from this study with the clinical procedure of microabrasion, the passive application of the microabrasive systems, which resulted in an increase in the roughness values when compared to the control group, shows that the clinician should be careful in not overly exposing the enamel surface to the microabrasive compounds without mechanical application. This finding suggests that the use of mechanical application helps to guarantee the scattering and renewing of the acid on the enamel, without allowing the erosive substance to remain on the tooth surface for too long. This concern is especially important in the case of patients with fluorosis stains or remineralized white spots, which are common after finish orthodontic treatment.[4,7] In these cases, the clinician should perform the procedure individually on each tooth, ensuring the renovation of the microabrasive mixture over the enamel surface to be treated, thereby reducing any extraneous erosive action, which is evident when the compounds are only placed on enamel.

The results of the present study, as well as those found in the literature, indicate that the microabrasive technique is a conservative esthetic procedure that may be safely indicated, although it causes alterations on the enamel surface. Therefore, it is important to study the technique, the microabrasive compounds and their effects on enamel, in order to reverse these effects and to obtain the most minimally invasive technique possible.

Conclusion

In conclusion, the results found in this study demonstrate that enamel microabrasion with different compounds results in an increase in the surface roughness of enamel. The association of HCl with AlO_3 resulted in an increase in surface roughness, when analyzed by SEM The passive application of the microabrasive systems enamel was an important point to be evaluated, since the results showed the care that must be taken when using the technique, in order to avoid the extraneous erosive action of the acid on the enamel surface.

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