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Surface Roughness and Enamel Loss with Two Microabrasion Techniques

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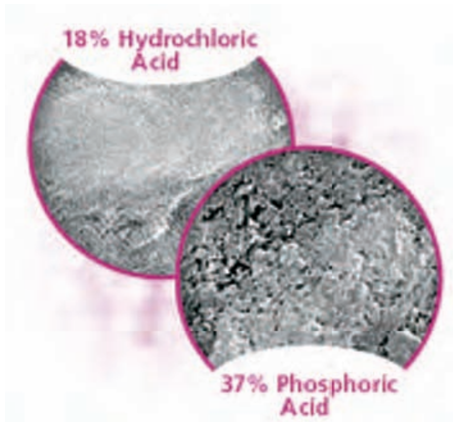

Abstract

Aim: The aim of this study was to evaluate and compare the surface roughness and enamel loss produced by two microabrasion techniques.

Methods and Materials: Bovine teeth were selected and an area was delimited for microabrasion techniques. Surface roughness was determined before and after treatment using a digital profilometer. Specimens were randomized to one of two acid treatments (n=10): 18% hydrochloric acid (HCl) and pumice or 37% phosphoric acid (H_3PO_4) and pumice. Acid treatments were applied using a wooden spatula for 5 seconds for a total of ten applications. Then, specimens were sectioned through the center of the demineralization area to obtain 80μm thick slices. The wear produced by the microabrasion techniques was evaluated using stereomicroscopy (40x). The greatest depth (μm) and the total surface area (μm^2) of demineralization were measured using the Image Tool software (University of Texas Health Science, San Antonio, TX, USA). In addition, three specimens of each group were subjected to SEM analysis at different magnifications.

Results: The mean surface roughness was statistically lower for HCl than for H_3PO_4 ($p<0.001$). Deeper demineralization ($p<0.003$) and a larger total demineralization area was observed for HCl ($p<0.005$). Under SEM analysis H_3PO_4 showed a selective conditioning etching, while HCl exhibited a non-selective pattern.

Conclusions: Microabrasion using H_3PO_4 produced greater surface roughness but less demineralization than the microabrasion technique using HCl.

Clinical Significance: Both microabrasion techniques effectively remove the superficial enamel layer. However, the technique using H_3PO_4 was less aggressive, safer, and easier to perform.

Keywords: Enamel microabrasion, phosphoric acid, H_3PO_4, hydrochloric acid, HCl, laboratorial research

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Introduction

Microabrasion using a paste made of acid and pumice is a technique used to remove white, yellow, and brown stains from enamel.[1] The method is safe, easily performed, effective, and causes no discomfort for the patient, thereby, improving the appearance of teeth by removing stains in the outermost layer of enamel.[1,2] The technique was first proposed by Croll and Cavanaugh[3] using a paste composed of 18% hydrochloric acid (HCl) and pumice applied to the affected area. The chemical action produced by the acid and the mechanical action from the abrasive will simultaneously erode and abrade the enamel surface.[4] Long-term evaluations have demonstrated the clinical success of such treatment for stain removal.[2,5] More recently, this technique has been used together with carbamide peroxide bleaching with improved results.[6,7]

Advantages of microabrasion are limited wear of the abraded enamel and the formation of a glasslike luster producing an exceptionally smooth texture[4] that might be more resistant to demineralization and *S. mutans* colonization when the microabrasion is followed by topical fluoride application.[8] The treatment also has the ability to prevent the staining recidivate and does not affect tooth vitality. However, HCl is an extremely aggressive and volatile agent and its application requires caution to avoid hazards to the patient or the professional.[9]

Other microabrasion techniques have been proposed using different concentrations and types of acid. PREMA (Premier Dental Co., Plymouth, PA, USA) is a marketed paste composed of 10% HCl and fine-grit silicon carbide particles in a water-soluble paste showing predictable results.[2]

The purpose of the microabrasion technique is to remove staining with minimal enamel loss. Enamel wear caused by different techniques is

a concern for esthetic dentistry. Several studies have evaluated the amount of enamel lost after microabrasion treatment.[10-13] Dalzell et al.[14] investigated the number of applications, pressure, and time, with a combination of 18% HCl and pumice, and found the amount of enamel lost was greater when each of these variables was increased. Using polarized light microscopy Tong et al.[13] reported 18% HCl alone produced enamel wear of 100μm (±47μm), which is significantly increased to 360μm (±130μm) when pumice is added to the technique. However, Chan and co-workers[15] did not detect a significant increase in surface roughness when enamel was treated with PREMA.

The replacement of HCl by phosphoric acid (H_3PO_4) in microabrasion techniques was first proposed by Mondelli et al.[16] The advantages of H_3PO_4 are its availability in dental offices for routine use in bonding procedures and fewer hazards as compared to HCl. Generally, the enamel demineralization produced with H_3PO_4 application is restricted to 5.7μm (±1.8μm).[13] When evaluating the effectiveness of this technique *in vivo* on enamel surface alterations, Matos et al.[17] found a satisfactory clinical result. Under SEM examination, the enamel achieved a surface smoothness after polishing with disks (Sof-Lex, 3M ESPE, St. Paul, MN, USA).[17] Comparing the surface roughness after microabrasion with phosphoric or HCl, Tagliari et al.[18] observed both materials reduced the enamel roughness and there were no significant differences between the techniques tested.

The aim of this study was to compare the surface roughness and the amount of enamel loss following two microabrasive techniques with H_3PO_4 or HCl, testing the null hypothesis that the two acids could produce similar roughness and enamel loss.

Methods and Materials

Specimen Preparation

Twenty recently extracted bovine incisors were selected. The teeth were cleaned, disinfected, and stored in saline at 4°C until use. Specimens were embedded in acrylic resin, and the buccal surface of each tooth was ground with a sequential grit silicon carbide paper (#600-1200) under running water (Figure 1). Specimens were randomly divided into two groups (n=10) according to microabrasion treatment: GI: 18% HCl and pumice; or GII: 37% H_3PO_4 and pumice. The surface area treated by microabrasion (5 mm diameter) was isolated using adhesive tape. Both abrasive pastes were applied over the isolated enamel surface with a wooden spatula for 5 seconds, followed by a 20 second washing with tap water. Ten applications were performed for each specimen in each group. Only one calibrated operator performed the microabrasion procedures to avoid a difference in pressure during treatments.

Surface Analysis Evaluation

Surface roughness (Ra) was measured with a profilometer (Surfcorder SE 1200, Kosaka Laboratory Co., Tokyo, Japan). For each specimen, five measurements in different directions were made with a cutoff value of 0.8 mm. Before starting the measurements, the profilometer was calibrated against a reference block (3.10 ± 0.10μm). The measurements were made before (Ra1) and after (Ra2) the microabrasion treatment. Roughness values were obtained with the formula Ram=Ra2–Ra1.

Enamel Loss Evaluation

After roughness readings, the specimens were cleaned and sectioned longitudinally through the center of the demineralized area to obtain one slice for each specimen. The slices were ground with a sequential grit silicon carbide paper

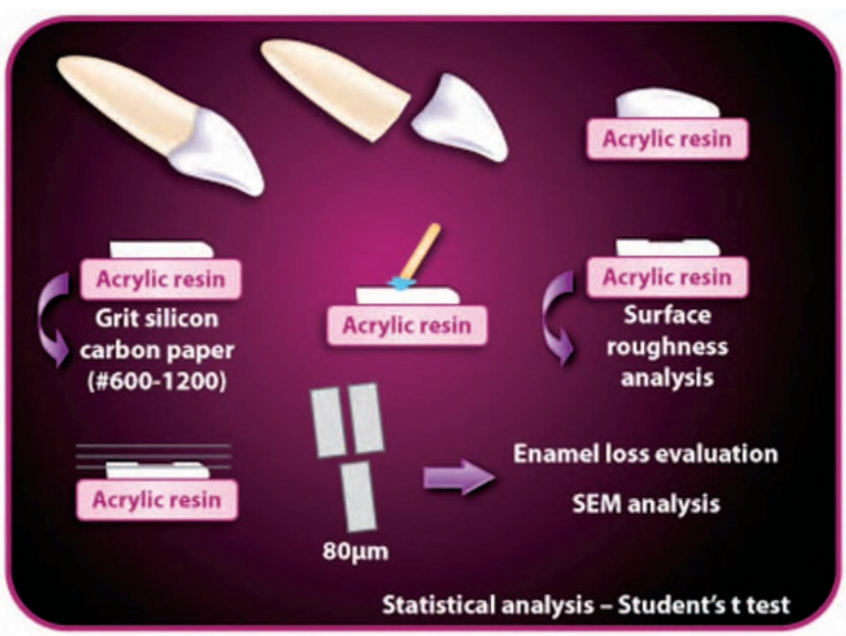

Figure 1. Schematic drawing of the experimental set up.

(#600-1200) under water cooling, to produce an 80μm thickness, confirmed by a digital caliper. The sections were mounted in histological slides and observed in a stereomicrocope adapted to a digital camera. Each specimen picture was captured along with a millimeter scale and digitized images were transferred to Image Tool software (San Antonio Dental School, University of Texas Health Science, San Antonio, TX, USA). The software was used to measure (40X magnification) the depth of enamel demineralization in μm and the total area of demineralization in μm^2.

SEM Evaluation

Three specimens from each group were randomly selected for SEM analysis. The specimens were fixed, dehydratred, and dried, using glutaraldehyde, an alcohol sequence and HMDS, respectively. Each specimen was mounted on an aluminum mounting stub (Electron Microscopic Science, Hatfield, PA, USA) and sputter-coated with platinum-gold and examined under a JEOL JXA 6400 (Japan). SEM pictures were taken with different magnifications at a working distance of 19 mm and an accelerating Voltage of 20.0 kV.

Statistical Analysis

Student's t test was used to determine statistically significant differences regarding surface roughness, demineralization depth, and total demineralized area between the two groups after microabrasion treatment with a significance level of $p < 0.05$.

Results

The mean values for surface roughness (Ram-μm), demineralization depth (μm), and total demineralization area (μm^2) in both treatment groups are shown in Table 1.

GII (H_3PO_4) had a rougher surface (1.4±0.2) compared to GI (HCl) (0.9±0.2) ($p<0.001$). Before the microabrasion procedure there was no significant difference in surface roughness between specimens allocated in GI (0.3 ± 0.1) and GII (0.4 ± 0.1) ($p>0.05$). There was significantly deeper demineralization for GI (HCl) ($p=0.003$). Additionally, the enamel loss with GI (HCl) treatment was greater than the GII (H_3PO_4) treatment ($p=0.0002$).

SEM analysis demonstrated different conditioning patterns for the two acids employed for the microabrasion techniques. The enamel surface abraded with GI (HCl) showed a smoother surface, with a non-selective conditioning (Figures 2 and 3).

Specimens in GII (H_3PO_4) exhibited a characteristic selective conditioning with a rougher enamel surface (Figures 4 and 5).

Discussion

Both microabrasion techniques tested produced demineralization in the superficial layer of enamel. Previous studies have reported a highly polished surface of enamel following abrasion with HCl and pumice, enhancing the esthetic appearance.[1,4,15] However, the current study showed both techniques increased the surface roughness, finding the enamel treated with H_3PO_4 produced a rougher surface than enamel treated with HCl. The increased roughness observed with H_3PO_4 could be attributed to a less aggressive decalcification, producing a selective conditioning pattern on the enamel surface and leaving a more granular and irregular surface.[19] Such findings are supported by the SEM analysis of this study, where a characteristic selective conditioning pattern was observed when enamel was submitted to microabrasion with H_3PO_4 acid.

Table 1. Mean (±SD) values of surface roughness (Ram-μm), demineralization depth (μm), and total demineralization area (μm2) of the different microabrasion techniques.

Microabrasion Technique	Surface Roughness Mean (±SD)	Demineralization Depth Mean (±SD)	Total Demineralization Mean (±SD)
18% HCl + pumice	0.9 ± 0.21	94.6 ± 22.7	$5.9 \times 10^5 \pm 1.3 \times 10^5$
37% H_3PO_4 + pumice	1.4 ± 0.22	48.0 ± 17.8	$2.9 \times 10^5 \pm 0.9 \times 10^5$

Figure 2. Enamel submitted to microabrasion using 18% HCl. A non-selective conditioning is observed (X 5000).

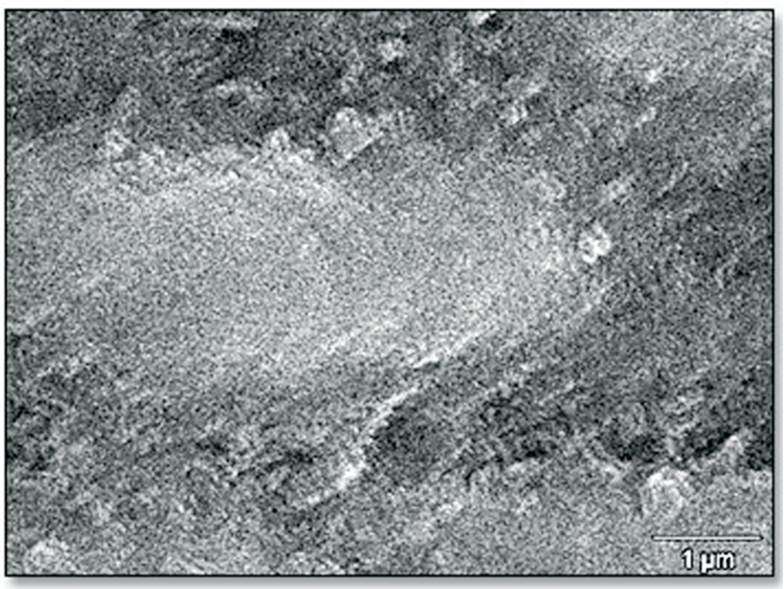

Figure 3. Enamel submitted to microabrasion using 18% HCl. The enamel surface was demineralized similarly, independent of the different morphological structures present in this tissue. A smoother surface is observed (X 15000).

Figure 4. Enamel submitted to microabrasion using 37% H_3PO_4. The enamel surface presents a characteristic selective conditioning pattern (X 5000).

Figure 5. Enamel submitted to microabrasion using 37% H_3PO_4. The H_3PO_4 acid conditioned differently the various compounds of the enamel tissue producing a rougher surface (X 15000).

In contrast, HCl is a more aggressive acid and did not result in selective etching, demineralizing equally the enamel surface, and producing a surface with lower roughness.[20] Similarly, SEM evaluation demonstrated a non-selective pattern for enamel submitted to microabrasion with HCl, with the dissolution of the entire enamel surface, despite the differences in morphologic composition of enamel. This non-selective conditioning may justify the lower surface roughness observed for this microabrasion technique compared to using H_3PO_4. However, Tagliari et al.[18] in a similar study reported different findings. Using similar techniques, HCl and H_3PO_4, with the same number of applications (12x for 10 seconds) they observed decreased enamel roughness, without significant differences between the two acids. Since the effect of time, number of applications, and pressure can effectively influence the amount of enamel loss, the methodological approach employed in each of these studies could account for the different results obtained.[14]

When evaluating the total enamel loss and demineralization depth produced by the different microabrasion techniques, higher demineralization was produced after HCl application. Similar results were observed by Mendes et al.[11] in which higher enamel wear (295.5μm) was detected when applying pumice and 18% HCl compared to 37% H_3PO_4 and pumice (142.87μm) with ten applications of 5 seconds. The higher demineralization produced in the Mendes study could be due to the different application technique. While the mixture was easily applied with one spatula in this study, a mechanical application with rubber points was used in the former study. The method of application can significantly influence the enamel loss.[21]

In another study comparing the direct application on enamel, Tong et al.[13] reported 18% HCl produced a mineral loss of 100μm (± 47μm), while the enamel loss with 37% H_3PO_4 was only 5.7μm (±1.8μm) when both acids were applied alone. The lower demineralization produced by H_3PO_4 could be related to two main factors: (1) less caustic effect when compared to HCl[22] with a lower capacity to remove mineralized structure in depth[11] and (2) selective action over the enamel prisms producing variations in the patterns of the conditioned surfaces.[19] However, in a clinical study comparing the efficacy of 18% hydrochloric or 37% phosphoric acids to remove enamel opacities, using a computerized analysis, it was concluded both acids could be used resulting in enamel color improvement.[23]

Microabrasion with H_3PO_4 produced a lower amount of enamel loss. Removal of 100μm of enamel is sufficient for the elimination of superficial enamel stains.[11] Based on these considerations, the microabrasion technique using H_3PO_4 seems to be an effective alternative to the application of HCl exhibiting good clinical results.[16,17] In addition to more enamel preservation with H_3PO_4 other advantages should be taken into account with this technique. H_3PO_4 is readily available in dental offices because of its use in adhesive procedures. Also, H_3PO_4 is less aggressive and poses fewer risks to the patient and to the dental team when compared to HCl. In a recent report, microabrasion technique was highlighted as a micro-invasive procedure and should be used with caution to avoid excessive tooth structure removal.[24]

A review of the current status of enamel microabrasion after 18 years found dental microabrasion a highly satisfactory, safe, and effective procedure.[25]

Despite the good results produced in laboratory studies, further longitudinal randomized clinical trials should be conducted to compare the efficacy and safety of hydrochloric and phosphoric acids used for enamel microabrasion.

Conclusions

Within the limitations of this study, it was concluded:

1. Both microabrasion techniques using HCl and H_3PO_4 increased enamel roughness with H_3PO_4 producing a rougher surface.
2. Enamel loss was significantly higher with HCl compared to H_3PO_4.

The null hypothesis tested was rejected since both techniques showed differences in surface roughness and enamel loss.

Clinical Significance

Both microabrasion techniques effectively remove superficial enamel layer. However, the microabrasion technique using H_3PO_4 is less aggressive, safer, and easier to perform.

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