The effects of microabrasion on demineralization inhibition of enamel surfaces

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Abstract

Microabraded enamel acquires a highly polished surface of mineralized tissue. The purpose of this study was to determine if microabraded enamel surfaces are more resistant to demineralization. Twenty extracted permanent incisors were used in the experiment. Four treatment modalities were investigated: (1) microabrasion in conjunction with a topical fluoride treatment, (2) topical fluoride treatment, (3) microabrasion, and (4) no treatment. All surfaces, following their respective treatment regimen, were stored in artificial saliva for 2 months and then exposed to an artificial caries system for 5 days. Teeth treated with microabrasion followed by a 4-minute application of 1% neutral topical sodium fluoride exhibited significantly less enamel demineralization when subjected to an artificial caries challenge than did teeth that underwent microabrasion alone, topical fluoride treatment alone, or no treatment at all. (Quintessence Int 1997;28:463-466.)

Clinical relevance

Microabrasion has proven to be a useful adjunctive or alternative treatment in esthetic dentistry. The current findings indicated that this type of treatment does not weaken the enamel surface but rather renders the surface more resistant to demineralization.

Introduction

Dentistry, over the past decade, has gone through many changes. The clinician has to be aware of contemporary techniques and materials in the field of operative dentistry as they become available. Patients of all ages demonstrate an increased concern with facial esthetics. Dentistry has been able to provide various alternatives to correct or enhance the appearance of unesthetic anterior teeth. Traditionally, porcelain-fused-to-metal crowns and porcelain jackets were the only options available for anterior restorations. Resin composite and porcelain veneer restorations were then developed and became additional alternatives. All of these restorations provide excellent dental care; yet the procedures are considered invasive because the reduction of significant amounts of tooth structure may be necessary.

Many patients complain to the dentist about unsightly discoloration of their anterior teeth. Discoloration can result from different entities. One contributing factor can be extrinsic staining, such as the accumulation and adherence of foreign particles. Another factor can be intrinsic staining, such as that caused by dentinogenesis imperfecta or the use of tetracycline during amelogenesis. Trauma to the primary teeth can also affect the developing color and structure of the permanent teeth. The use of excessive fluoride can result in mottled and pitted enamel, frequently known as fluorosis.¹ Croll² described other discolourations that can result from abnormal mineralizations. The maturing enamel can exhibit brown opacities, white opacities, or multicolored tooth defects. Croll³ has termed this phenomenon enamel dysmineralization.

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Many reports have been published describing techniques to remove such discolorations. Initial attempts to modify enamel color included obliteration of the outer enamel, either by chemical dissolution with mineral acids or the mechanical means of grinding. A technique recommended for removal of enamel discoloration is microabrasion. This technique originally involved using a solution of hydrochloric acid and pumice. It might be expected that modifying the surface layer of enamel with a finishing bur could also remove enamel discoloration, but equivalent results have not been shown to be obtained with bur cutting of the enamel. The microabrasion technique offers a conservative approach that has minimal enamel surface loss.

Studies have been completed observing histologic changes of the enamel after treatment with microabrasion. The surface appears to exhibit a layer of mineralized tissue not demonstrating the natural external prism morphology. This surface smear layer has been referred to as the abrasion effect. The surface layer also exhibits a smooth surface. Donley et al postulated that, because the surface acquires a polished mineralized layer, the treated enamel may be more resistant to demineralization.

The purpose of this study was to investigate whether microabrasion of enamel surfaces can inhibit demineralization.

Method and materials
Twenty extracted permanent maxillary central incisors were stored in 0.1% thymol solution until the experimental procedure was initiated. Each tooth was cleansed with pumice and water. The 20 teeth were randomly divided into two groups (groups I and II). The facial surfaces of all teeth were divided into halves. The mesial half of the facial surface was treated with five applications of PREMA Compound (Premier Dental), as directed by the manufacturer. Group I received a 4-minute treatment of 1% neutral sodium fluoride gel after microabrasion; group II received no fluoride. The mesial half of the facial surface was the microabraded (treated) site, designated as subdivision a. The non-microabraded distal half of the facial surface was designated as the control site on each incisor, designated as subdivision b.

The teeth were then suspended in synthetic saliva for 2 months. This artificial saliva contained 20 mmol/L sodium bicarbonate, 3 mmol/L sodium phosphate, and 1 mmol/L calcium chloride dihydrate and deionized water. The pH of the solution was adjusted to 7.0. After 2 months, the teeth were painted with an acid-protective varnish, excluding a 2 x 8 mm window on the labial surface, extending mesiodistally to include treated and control areas. The teeth were then suspended in an acidified solution for 7 days at a pH of 4.2.

A hard-tissue microtome was used to cut longitudinal sections, labiolingually, to obtain 100-μm sections from the treatment and control sites. The sections were examined and photographed under polarized light microscopy with water as the immersion media (refractive index: 1.33). Areas of demineralization were calculated with a computerized digitizer. The depth was also measured from the advancing front of the body of the lesion to the enamel surface.

The data were analyzed with an analysis of variance (ANOVA) and Duncan's Multiple Range Test.

Results
In vitro results demonstrated that enamel surfaces that were microabraded and treated with 1% neutral sodium fluoride exhibited less demineralization than did the remaining groups. The mean areas (μm² ± SD) of demineralization were: group Ia (microabrasion and fluoride treatment), 9.15 ± 1.28 x 10^3; group Ib (fluoride treatment alone), 3.93 ± 1.5 x 10^3; group IIa (microabrasion treatment alone), 2.37 ± 2.59 x 10^3; and group IIb (no treatment), 7.52 ± 5.73 x 10^3.

The mean depths (μm ± SD) of the lesion for each group were: Group Ia, 16.25 ± 19.07; group Ib, 42.32 ± 34.24; group IIa, 30.27 ± 34.68; and group IIb, 76.55 ± 40.23.

The ANOVA demonstrated a significant difference among groups for the area of demineralization and the depth of the lesion (P < .005). Duncan's Multiple Range Test indicated that surfaces that were microabraded, followed with a 4-minute 1% neutral sodium fluoride treatment (group Ia), exhibited significantly less enamel demineralization when subjected to an artificial caries challenge than did surfaces only treated with 1% neutral sodium fluoride (group Ib) or surfaces that received no treatment as controls (group IIb), at a confidence level of P < .05. The test also indicated that surfaces that were only microabraded (group IIa) exhibited significantly less demineralization than did surfaces that received no treatment and acted as the control (group IIb) (P < .05).

Duncan's Multiple Range Test indicated that surfaces that were microabraded and treated with 1%...
neutral sodium fluoride (group Ia), surfaces that were treated only with 1% neutral sodium fluoride (group Ib), and surfaces that were only microabraded (group Ila) exhibited significantly less lesion depths than did surfaces that acted as the controls (group IIb). \( P \leq 0.05 \). Figures 1 to 4 are polarized light photomicrographs representing each treatment modality after being subjected to an artificial caries system.

Discussion

Microabrasion is an alternative to an invasive procedure for removal of enamel discolorations. The data from this study showed that enamel surfaces that were microabraded and treated with 1% neutral sodium fluoride were more resistant to demineralization. The demineralization inhibition effects shown in the study are most likely related to several factors.

One of the factors that may explain the mechanism that produces a more insoluble enamel surface involves the etching effects of the acid and abrasive compound. Studies have examined the etching effect that acid has on enamel surfaces. Silverstone et al. observed the changes under the scanning electron microscope. Three different etching patterns were observed. Type 1 presents with hollowing of the prism center; the peripheral regions were left intact. Type 2 presents with the absence of the peripheral regions surrounding the prism core. Type 3 exhibits a generalized roughness, with characteristics similar to those of types 1
and 2. Kendell\textsuperscript{10} observed a type 2 pattern, with a preferential loss of the prism peripheries.

Perhaps the etching effect of the microabrasion compound alters the enamel prism structure, allowing mineral by-products to be compacted in the prism periphery. The etching pattern may also provide a pathway for dissolution of subsurface enamel, which, with minerals from external fluids, may reprecipitate and enhance remineralization. The acid and abrasive mixture in conjunction with fluoride treatment may also contribute to the formation of fluorapatite. The formation of fluorapatite crystals can enhance remineralization and diminished solubility.

Another possible effect of the microabrasion technique is the creation of a smear layer during application of the compound. Each application of the abrasive compound removes approximately 25 \(\mu\text{m}\) of enamel.\textsuperscript{11} This mild surface abrasion of enamel prisms may cause mineral by-products to be compacted on the enamel surface, making the enamel more resistant to demineralization.

Previous research by Donly et al\textsuperscript{7} demonstrated that microabrasion creates a surface that exhibits positive birefringence when the specimens are examined under polarized light microscopy. The newly formed surface appears as a dark layer when imbed in water (refractive index: 1.33). The surface also appears to be intact. Chan et al\textsuperscript{12} questioned whether the layer produced after several applications of the PREMA compound was a mineral layer. They attributed this layer to the edge effect, which would be caused by the enamel section's being too thick and thus causing a shadow in light microscopy. Donly et al\textsuperscript{7} did not believe that the dark surface area in water imbibition was an edge effect because it disappeared when the surface was imbibed in quinoline.

Polarized light cannot be utilized to explain the histopathologic and morphologic changes taking place. The polarized light merely demonstrated a positive birefringent surface, which meant the surface enamel had been altered from a natural state. Scanning electron microscopy demonstrated that the enamel surface did develop a highly polished surface with no evidence of interprismatic spaces.\textsuperscript{7} A comparison was made among natural enamel and enamel after 10 and 20 microabrasion applications. After treatment, the surface was smoother and appeared to have mineral by-products surrounding prisms.

A cross-sectional view indicated a surface "Smear layer." Although this newly formed surface is probably in the range of 15 \(\mu\text{m}\) thick, there is no surprise that this could inhibit demineralization. It is known that the most enamel uptake of 1.23% acidulated phosphate topical fluoride is in the outer 10 \(\mu\text{m}\). There is no question that the outer enamel, following exposure to topical fluoride, inhibits caries. The smoothing of the enamel surface, the creation of a smear layer, and the incorporation of fluoride into enamel all appear to have the combined effect of inhibiting demineralization.

These different mechanisms may explain why microabraded surfaces, when challenged by an artificial caries system, had a smaller mean area and depth of demineralization.

**Summary**

The surfaces that were microabraded and subsequently treated with a 4-minute application of 1% neutral topical sodium fluoride exhibited significantly less enamel demineralization, when subjected to an artificial caries challenge, than did surfaces treated with microabrasion alone or topical fluoride treatment alone or surfaces given no treatment at all. Future research may evaluate the findings of this study in vivo.

**References**