The Effect of Micro Abrasion for Color Modification on the Topography and Acid Resistance of Enamel

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Introduction
Enamel microabrasion is a method of removing certain enamel dysmineralization and decalcification defects [1]. Enamel dysmineralization can sometimes be determined in case of white or brown stain fluorosis [2]. In addition, certain white decalcification enamel lesions may be due to chronic stasis of dental plaque. Such lesions are commonly seen after the removal of resin-bonded orthodontic brackets or cemented bands [3]. These stains may have a tremendous psychological impact on the patients.

The use of acid microabrasion technique has been extensively described for the treatment of enamel staining, and its success in achieving immediate color modification is generally agreed [4, 5].

McClosky [6] has described a simple and seemingly effective method of eliminating brown fluorosis stain from cosmetically prominent enamel surfaces using 18% hydrochloric acid. The technique was slightly modified by Croll and Cavanaugh, [7] by controlled hydrochloric acidpumice microbarasion for enamel color modification. Bishara et al. [8] suggested this procedure to eliminate superficial enamel stain and decalcification following the completion of orthodontic treatment. They concluded that this approach is not indicated for deep lesions or for generalized enamel and dentine stains such as tetracycline staining and devitalized teeth.

Kilpatrick and Welbury [9] concluded that this technique, if used with care, is a quick, safe and economically viable for treating certain forms of enamel discoloration.

The mechanism by which this technique achieves its color changes is by removing the surface enamel. The amount of enamel removed depends on the duration of the treatment. Reported values from laboratory investigations vary, Welbury and Shaw [10] found that after five

“5-second” applications of 18% hydrochloric acid with pumice, the enamel loss were 54.4 µm, and after 10 applications, the depth loss was 73.9 µm.

Others [11] have found the loss in depth of enamel to be significantly greater; they showed that after ten “5-second” applications, one-quarter of the thickness of the labial enamel was removed. However, they concluded that this loss was probably not clinically significant. In another laboratory experiment, scanning electron micrographic analysis of multiple samples of acid-pumice treated enamel revealed that enamel was removed by chemical and mechanical abrasion [12]. However, the patterns resulted from the chemical reactions eroding the enamel prisms, need more investigations.

Many attractive smiles are marred by some discoloration or staining, either on an individual tooth or on all teeth. Isolated yellow, brown, or white areas on an otherwise normal enamel surface, though, are common. Improved materials and techniques have been developed to remove or mask discoloration to solve these unaesthetic conditions [13].

Most clinicians avoided the use of acids because they feared damage to, and destruction of enamel. Which would render the teeth more susceptible to caries [10].
Since the surface enamel contains the greatest fluoride concentrations, [14] the loss of fluoride rich surface enamel during microabrasion procedure may make the enamel more susceptible to decalcification.

Proposed treatments, depending on the severity of the enamel stains [15] range from invasive ceramic veneer bonding restorations to abrasive chemical treatments. Although aesthetic demands for perfect [16] smiles are increasing, economic problems have treatment options. More conservative approaches based on cheaper and less time-consuming treatments such as bleaching, micro-abrasive treatments and composite resin restorations are widely used.

**Aim of the Work**
The purpose of this study was to investigate:

I- The effect of microabrasion on:
   1. The topography of the enamel surface.
   2. The acid resistance of enamel (caries susceptibility).

II- The effect of fluoride application after acid microabrasion on the enamel.

**Material and Methods**
Thirty sound premolars for orthodontic purposes were collected and stored in tap water at 4°C. The teeth were divided into two groups, each contained 15 teeth:

**Group I:** Enamel microabrasion was done without fluoride application.

**Group II:** Enamel microabrasion was done followed by 2% sodium fluoride (NaF) application.

All the teeth were sectioned longitudinally along the buccolingual plane using a diamond disc into two halves. One half was used as a control, and received no treatment, but was only cleaned with rubber cups and pumice, while the other half (test) was subjected to hydrochloric acid/pumice microabrasion procedure.

The tooth halves were covered with nail varnish except for a circular window of 3 mm in diameter on the buccal surfaces (Figure 1).

**Figure 1:** Varnished Buccal Surface of a Tooth, Showing Two Windows of Enamel of a Known Dimension (before sectioning)

**Enamel Microabrasion Procedure** [8]

1) The buccal surface of the tooth half was thoroughly cleaned with a prophylaxis rubber cup and an aqueous slurry of pumice using the conventional speed and then washed thoroughly.

2) Eighteen percent (18%) hydrochloric acid mixed with pumice powder into a slurry, was applied with a wooden stick and rubbed over the buccal surface of the teeth in an erasing motion for 5 seconds.

3) The slurry was then washed off with water.

4) The procedure was then repeated for 10 applications.

5) In group (I), a fine rinse for 30 seconds was done, followed by polishing the enamel with Vivadent green cup using fine prophylactic paste.

6) In group (II), a fine rinse for 30 seconds, was followed by 2% NaF solution application for 3 minutes. Then, enamel was polished with Vivadent green cup using fluoride solution as lubricant. Finally, fine prophylactic paste was used to polish the enamel surface.

**Enamel Topography:** (6 Premolars)

Following microabrasion procedure, the tooth halves (test and control) in both groups, were dehydrated in different grades of alcohol. Therefore, they were air-dried, then mounted on metal stubs and sputtercoated with 20 to 30 nm of gold, for 4 minutes in “Fine-Coat ion Sputter5 JFC-1100”. The thickness of gold was 200 nm.
The teeth were examined following the critical point drying technique by “JEOL JSM 25 SII Scanning Electron Microscope”.

**Determination of Acid Resistance of Enamel**

Acid resistance of enamel was investigated by the determination of enamel dissolution after microabrasion procedure quantitatively and qualitatively.

The quantitative assessment of enamel demineralization was undertaken by measuring the amount of calcium dissolved in perchloric acid using the “Atomic Absorption Spectrophotometer”, while the qualitative assessment of enamel demineralization was obtained by using a “Polarized Light Microscope” to examine the formation of artificial caries-like lesions.

**Quantitative Assessment Procedure[17]: (16 Premolars)**

- Following microabrasion procedures in the two groups, the tooth halves were mounted on plastic rods by sticky wax and covered with nail varnish.

  - Each enamel specimen was etched with 1 ml of 0.5 M perchloric acid for 30 seconds at room temperature. The same procedure was done for the control halves. After the addition of 4 ml of “TISAB” (total ionic strength adjustor buffer) solution, 1 ml of the solution was diluted with 9 ml of 0.2% lanthanum oxide to eliminate interference by phosphates.

  - The amount of dissolved calcium in the acidic solution was determined with an “Atomic Absorption Spectrophotometer”. The surface area of the lesion windows was calculated and calcium loss per unit area was determined (µg / mm²).

  - The acid resistance of the enamel was determined by the ratio of dissolved calcium from the enamel surface of treated and untreated controls.

**Qualitative Assessment Procedure[18]: (8 Premolars)**

- Following microabrasion procedure in both groups, each tooth half was placed in 60 ml freshly prepared demineralized solution (lactate buffer), composed of 0.1 M / L lactic acid, 11.7 m M / L calcium (CaCl₂ 2 H₂O), 6.0 m M / L phosphate (KH₂PO₄), the pH was adjusted with KOH to 4.3. The teeth halves were then suspended in the solution, unstirred at 25°C.

  - After 72 hours, the teeth halves were removed and rinsed with distilled water. Thin sections of enamel (180 µm) were then cut perpendicular to the window areas with a diamond disc. After this, the sections were ground by hand using grinding paper to a final thickness of approximately 100 µm.

  - Assessment of the lesion depth was obtained by using a “Polarized Light Microscope” to examine the sections after imbibition in water. Standard photomicrograph was taken for each specimen.

The data were statistically analyzed using the t-test and the results of SEM and the Polarized Light Microscope were presented in photographs.

**Results**

**Enamel Topography**

Scanning electron microscopic study of enamel surfaces after treatment as well as the control specimens which received no treatment are shown in Figure (2-11). The control specimens showed normal appearance of enamel which has a homogenous surface (Figure 2), with no signs of abrasion or erosion (Figure 3).

In group (I), examination of the microabrasive specimens, after 10 “5-second” applications of acid pumice, revealed a loss of surface integrity with eroded and abraded areas as shown in Figures 4,5. In Figure 6, the demarcation between erosion areas and intact enamel was evident. In the higher magnification, the enamel surface showed preliminary exposure of underlying enamel prisms with type-1 etch pattern (Figure 7).

In group (II)(microabrasion with fluoride), the treated specimens showed a heterogeneous layer of coarse – large and small – crystals which covered the underlying enamel prisms and obscuring them (Figures 8, 9). Higher magnification showed globular particles – together – with some exposed enamel prisms (Figures 10, 11).
Figure 2: Scanning Electron Micrograph of an Enamel Surface of a Control Specimen After Cleaning With a Rubber Cup and an Aqueous Slurry of Pumice, Showing Intact Surface [X 150]

Figure 3: Higher Magnification of Figure (2), Showing No Signs of Abrasion, Erosion or Exposure of Enamel Prisms [X 1000]

Figure 4: Scanning Electron Micrograph of Acid Pumice Microabrasion (Group I), Showing Loss of the Surface Integrity With Eroded and Abridged Areas [X 150]

Figure 5: Higher Magnification of Figure (4), Showing the Eroded Area [X 1000]

Figure 6: Scanning Electron Micrograph of a Specimen in Group (I), Showing a Line of Demarcation between Treated and Untreated Areas. The Treated Area Shows Abrasion and Erosion, Exposing the Underlying Enamel Prisms [X 45]

Figure 7: Scanning Electron Micrograph of an Enamel Surface Following Microabrasion (Group II). The Surface Shows Preliminary Exposure of The Underlying Enamel Prisms (Type I Etching Pattern [X 1000]
Determination of the Acid Resistance
Quantitative Assessment

The results of the amount of calcium ion determined by the “Atomic Absorption Spectrophotometer” in the two groups are summarized in Table 1.

The results are given as appearance in solution (µg) per unit surface area (mm²) of exposed enamel. The acid resistance was determined by the amount of Ca⁺⁺ released in the acidic solution. The increase in the amount of Ca⁺⁺ indicates decrease in the acid resistance of enamel.

In **group I**: (microabrasion without fluoride), the mean amount of calcium loss in the test halves was 1.13 µg / mm², while in the control halves, it was 0.56 µg / mm². The difference was statistically significant (P < 0.05).

Comparison between the two treated groups, regarding the decrease in acid resistance, is shown in Table II.

The mean difference in Ca⁺⁺ released from the test and control specimens in group I (0.57 µg / mm²), was slightly higher than that in group II (0.54 µg / mm²). The difference was not statistically significant (P > 0.05).

Following microabrasion 101.76% reduction in acid resistance of enamel was found in group (I), while 72.96% reduction was found in group (II).

II- Qualitative Assessment

Caries-like lesions produced by lactate buffer in the control and test groups, examined by “Polarized Light Microscope”, after imbibition in water, are shown in Gigs [12-19].

Qualitative comparison of the artificial caries-like lesions showed a clear distinction in the shape of the lesion in microabraded specimens as compared to the lesion in control specimens. In the control specimens, the body of the lesion can be seen in the sub-surface region adjacent (near) to the surface zone (Figure 12). Two dark zones were seen, the first is at the advancing front of the lesion and the second one near the lesion surface. Following microabrasion. In both groups, the body of the lesion can be seen as a wide dark zone of demineralization in the sub-surface region deep to the surface zone (Figures 13-16). However, evidence of starting remineralization was seen in Figures [18, 19] with fluoride application.

In addition to this qualitative changes observed, smaller lesion depths were seen in the enamel in the control group, compared to the test group. On comparing microabraded specimens with and without fluoride application, a slight reduction in the body area was seen in the lesion treated with fluoride after microabrasion.

Table 1: Mean Amount of Calcium (µg / Mm2) Dissolved In Perchloric Acid in the Two Groups, Compared to Their Controls

<table>
<thead>
<tr>
<th>Group</th>
<th>Test Mean ± S.D</th>
<th>Control Mean ± S.D</th>
<th>† test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>Microabrasion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Fluoride</td>
<td>1.13 ± 0.20</td>
<td>0.56 ± 0.20</td>
<td>5.53*</td>
</tr>
<tr>
<td>Group II</td>
<td>Microabrasion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Fluoride</td>
<td>1.28 ± 0.22</td>
<td>0.74 ± 0.26</td>
<td>4.40*</td>
</tr>
</tbody>
</table>

No. = 8
* Significant at 5% level.

Table 2: The Effect of Microabrasion in the two Groups on the Acid Resistance of Enamel

<table>
<thead>
<tr>
<th></th>
<th>Group I Mean ± S.D</th>
<th>Group II Mean ± S.D</th>
<th>† test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca++ Release*</td>
<td>0.57 ± 0.32 (101.76)**</td>
<td>0.54 ± 0.38 (72.97)**</td>
<td>0.17</td>
</tr>
</tbody>
</table>

No. = 8
* The mean difference in Ca++ released from test and control.
** Per cent of increase of Ca++ release, is given in parentheses.

Figure 12: Polarized Light Photomicrograph (Cross Nincone) of Control Specimen, Showing Caries-Like Lesion Developed Near the Surface as Two Dark Zones [X 100]

Figure 13: Polarized Light Photomicrograph of a Specimen Subjected to Microabrasion (Group I). It Shows a Wide Dark Zone of Demineralization in the Sub-Surface Region [X 100]

Figure 14: Higher Magnification of Figure 13, Showing the Lesion [X 150]
Discussion

Enamel microabrasion, a method of removing certain enamel dysmineralization and decalcification coloration defects, has been extensively described [17]. Its success in achieving immediate color modification is generally accepted. However, little information is available regarding the effect of such treatment on the enamel surface.

In the present study, the SEM analysis of enamel after treatment with the hydrochloric acid/pumice slurry revealed that the enamel was being removed and the surface was altered. After ten “5-second” applications with the acid/pumice, the enamel surface showed loss of surface integrity and preliminary exposure of underlying prisms. This result confirmed that of Olin et al, [12] who concluded also that the enamel was removed by chemical erosion and mechanical abrasion.

The amount of enamel removed appeared to be dependent on the contact time of the acid pumice. In this study, ten “5-second” application were used, which are the maximum interval suggested clinically. As each application is estimated to cause a total loss of enamel surface approximately 10 µm, and this procedure is recommended for treating superficial enamel to a maximum depth of 100 µm.(8) While when the number of applications was increased to twenty “five-second” applications, as reported by Olin et al, [12] the enamel displayed a complete abrasion and erosion of the surface with exposure of the underlying enamel prisms.

The etch patterns produced in the present study is similar to type 1 etching pattern using phosphoric acid, reported by Silverstone; [19] preferential etching of enamel rod cores. This finding was similar to Kendel, [20] who observed both type I and II etch patterns after “5-second application”.

Whenever enamel is removed, the potential for increased plaque accumulation on the roughened surface as well as an increased thermal sensitivity in cervical areas must be considered. Although many authors, [10, 11, 20] concluded that the amount of enamel lost by microabrasion was probably not clinically significant, however, the mechanical abrasion and erosion resulted from this procedure with subsequent roughness of the enamel, may help the formation of new extrinsic stains with time. Further clinical studies with long-term assessment should be done to verify this hypothesis.

Microabrasion followed by topical application of fluoride showed precipitation of an amorphous layer of crystals covering the underlying prisms and obscuring them. This picture indicated an initial stage of remineralization and protection of the enamel surface.

Regarding the effect of microabrasion on the acid resistance of enamel, this study indicated a significant reduction in the acid resistance of the microabraded enamel, as compared to the control. This was proved by the increase of Ca++ loss in the acidic solution. As the higher degree of mineralization, fluoride and lead content of the surface layer of enamel, which make it more resistant to acid dissolution, [21] was likely lost after the application of the acid/pumice mixture.

The decalcifying effect of the acid with the subsequent potential decrease in the acid resistance of the enamel, may render the tooth more susceptible to caries. However, the present study utilized intact, non-fluorosed teeth. When using this procedure to remove fluorosis
stains, it might be postulated that a fluorosed tooth would be more resistant to acid dissolution and, therefore, has a lesser amount of enamel loss than non-fluorosed teeth. On the other hand, this increase in caries susceptibility should be considered before applying this procedure in patients with poor oral hygiene and high caries susceptibility.

A slight improvement in the acid resistance of the enamel was demonstrated in the treated group following topical fluoride application, but this improvement was not significant. This finding was confirmed by the qualitative assessment in which fluoride affected the caries-like lesion development by inhibiting the demineralization process. Since previous in-vivo [22] and in-vitro [23] studies indicated that exposure of the etched enamel surface to saliva returned the value for acid dissolution to approximately normal. Further improvement in the acid resistance may be anticipated by the deposition of both organic and mineral substances from the oral fluid.

Topical fluoride application, following microabrasion procedure, is essential, and repeated applications may aid in additional remineralization and increase the acid resistance of the enamel.

Conclusions and Recommendation

From the results of the present study. It could be concluded that:
1) Ten sequential “5-second” microabrasions resulted in loss of surface integrity with the appearance of eroded and abraded areas. It also reduced the acid resistance of eroded and abraded areas.
2) Topical application of fluoride revealed starting remineralization with slight improvement in the acid resistance of the microabraded enamel. Repeated application of topical fluoride following microabrasion, is recommended to increase the acid resistance of the enamel through additional remineralization.

Summary

Enamel microabrasion is a method of removing certain enamel dysmineralization and decalcification defects.

This study was conducted to investigate the effect of microabrasion on the topography of the enamel surface and on its acid resistance (caries susceptibility) as well as the effect of fluoride application after acid microabrasion on the enamel.

Thirty sound premolars extracted for orthodontic purposes, were collected and stored in tap water at 4°C. The teeth were divided into two groups, each contained 15 teeth:

Group I: Enamel microabrasion was done without fluoride application.

Group II: Enamel microabrasion was done followed by 2% sodium fluoride (NaF) application.

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Following microabrasion procedure, enamel topography was studied by the Scanning Electron Microscope.

Acid resistance of enamel was investigated quantitatively by the Atomic Absorption Spectrophotometer and qualitatively by the Polarized Light Microscope.

The results showed a loss of surface integrity and exposure of the underlying enamel prisms with significant reduction in acid resistance after microabrasion. The results of this study indicates that fluoride application after microabrasion is important to compensate for the erosion of the enamel surface.

Reference


