Scientific Article

Microabrasion: effect of time, number of applications, and pressure on enamel loss

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Abstract

Enamel microabrasion using hydrochloric acid and pumice is an effective method to remove superficial enamel discoloration. This procedure is used in many dental offices but little is known about how different treatment combinations of hand applicator pressure on the tooth, number of applications, and duration of application affect the amount of enamel loss. This investigation studied variables of time, number of applications, and pressure individually and in combination. Twenty-seven extracted premolars were hand rubbed with an 18% HCL-pumice mixture at time intervals of 5, 10, and 20 sec and 5, 10, and 15 applications under pressures of 10, 20, and 30 g. Fifty-four longitudinal sections were cut from the treated sections and measured for enamel loss (P < 0.05). Enamel loss significantly increased as each variable separately increased. When two variables increased at the same time, a greater amount of enamel loss occurred than when one increased. The combination of 10 ten-sec applications or 15 five-sec applications with 20 g pressure resulted in enamel loss of slightly less than 250 µm. (Pediatr Dent 17:207–11, 1995)

A number of enamel microabrasion techniques utilizing hydrochloric acid (HCL) applied to the discolored areas alone or in a pumice mixture have been reported to be effective in removing superficial enamel discoloration.[1-3] Typically, these areas of discoloration are brown or white stains associated with fluorosis, surface etching around orthodontic bands, and idiopathic brown and white surface stains. Croll and Cavanaugh,[1] adapting McCloskey's[2] method, recommended a technique of sequential rubbing applications of a paste mixture of 18% HCL and pumice for superficial enamel stains on younger patients. While this technique provides significant esthetic improvement for surface stains, little information is known about what effect variables such as pressure, application time, and number of applications have on the amount of enamel lost during microabrasion.

Waggoner et al.[4] measured the amount of enamel lost during 10 successive rubbing applications of an 18% HCL and pumice mixture. He found that the acid mixture initially removes an average of 12 µm of enamel, with 26 µm removed with each subsequent application. Tong et al.[5] measured the enamel loss of 100 ± 47 µm utilizing a direct application of 18% HCL for 100 sec. Utilizing pumice and a rotary cup in conjunction with the 18% HCL contributed markedly to the enamel loss (360 ± 130 µm).

The purpose of this study was to measure the amount of enamel lost during successive rubbing applications of a paste mixture of 18% HCL and pumice using different treatment combinations of pressure of the instrument on the enamel, application time, and number of applications.

Methods and materials

Specimen preparation

This investigation used 27 extracted premolars removed from children aged 9–12 years for orthodontic reasons. None of these teeth showed visible signs of decalcification, fluorosis, or any other defects. For ease of handling, the crown was separated from the root of each tooth and was then cut into buccal and lingual halves. The buccal half was used and the lingual half was discarded. The right and left halves of the buccal segment were sanded lightly with a medium sand paper disc to provide a flat surface for measurement. The specimen was cleaned with light pumice, washed for 5 sec, and air dried. The specimen then was divided into an occlusal, a middle or treatment section, and a cervical section. The occlusal and cervical sections were covered with nail polish and sticky wax to protect the enamel from the HCL-pumice mixture. A narrow vertical strip of nail polish and wax was placed down the center of the cusp to separate the middle section into right and left treatment sections. Fifty-four treatment sections were prepared in this manner. The protected enamel served as the experimental controls. The HCL-pumice abrasive then was applied to the treatment sections as described by the protocol.

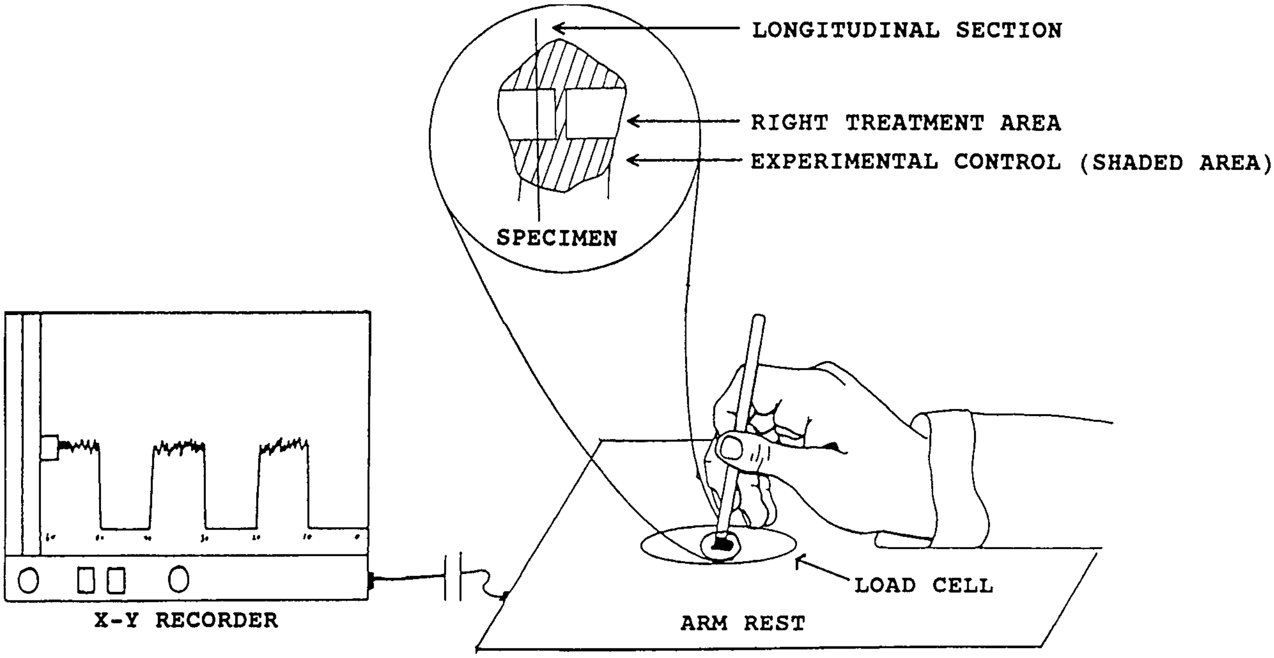

Fig 1. The abrasion apparatus with hand/arm rest, specimen affixed to the load cell, and X-Y recorder. The longitudinal shaded areas on the specimen represent those sections of the tooth covered with nail polish and sticky wax.

Abrasion procedure

The abrasion apparatus is shown in Fig 1. The prepared specimens were affixed with sticky wax to the platen of a load cell (Model 2511-201, Instron Engineering Corp., Canton, MA) calibrated for a full-scale reading of 50 g force. A special arm and hand rest was constructed to prevent any extraneous pressure reaching the load cell. A mixture of 1 ml of 18% HCL and 1 g of light pumice (Grade CL 125-fine, Whip Mix Corp, Louisville, KY) was hand rubbed on the enamel using a PREMA plastic hand applicator (diameter 3.0 mm, Premier Dental Products Co, Norristown, PA). The HCL-pumice slurry was applied at different intervals of time (5, 10, and 20 sec) and number of applications (5, 10, and 15) under pressures of 10, 20, and 30 g (Table 1). The specimen was washed 10 sec and dried with compressed air following each application. Circuitry allowed recording of the force levels on a X-Y recorder

Table. Enamel loss resulting from different microabrasion treatment techniques using 18% HCL and pumice.*

Time (sec)	*Pressure (g)*	*Depth of Enamel Loss (µm)*	*Time (sec)*	*Pressure (g)*	*Depth of Enamel Loss (µm)*	*Time (sec)*	*Pressure (g)*	*Depth of Enamel Loss (µm)*
5 Applications			*10 Applications*			*15 Applications*		
Group 1			Group 2			Group 3		
5	10	103	5	10	127	5	10	170
5	20	111	5	20	178	5	20	204
5	30	159	5	30	213	5	30	266
Group 4			Group 5			Group 6		
10	10	87	10	10	107	10	10	127
10	20	108	10	20	229	10	20	261
10	30	196	10	30	260	10	30	319
Group 7			Group 8			Group 9		
20	10	206	20	10	244	20	10	292
20	20	216	20	20	352	20	20	420
20	30	308	20	30	381	20	30	588

* Treatment combinations that resulted in enamel loss < 250 µm are shaded.

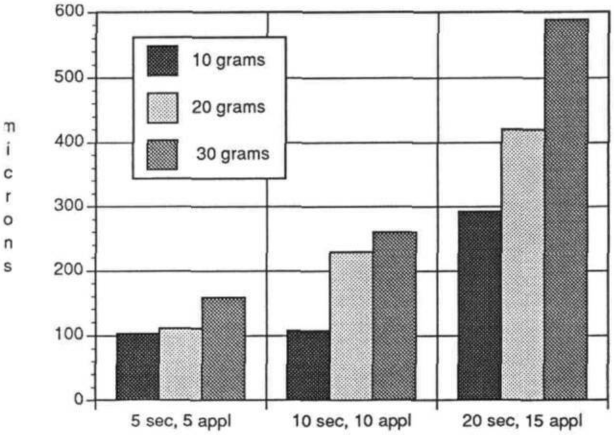

Fig 2. Bar graph illustrating enamel loss resulting from nine treatment combinations in which the variables, number of applications and time of applications increase at the same time under pressure of 10, 20, and 30 g.

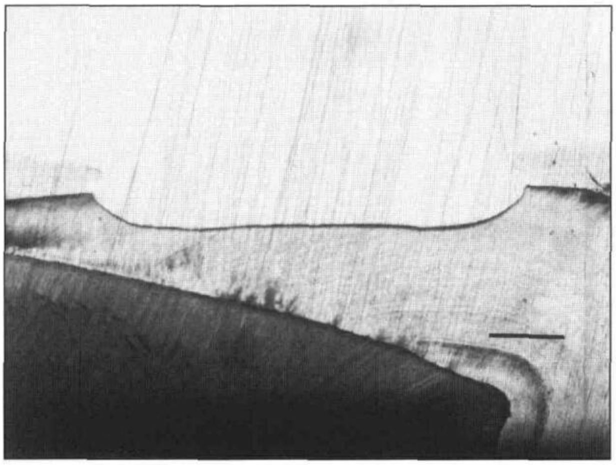

Fig 3. Low-power view of the buccal surface of a premolar specimen showing enamel loss of 204 μm following 15 five-second applications under 20 g pressure (40x; bar = 500 μm).

(Model 7005B, Hewlett-Packard, Palo Alto, CA) at a chart speed of 10 in./sec. This load cell/X-Y recorder arrangement served to standardize force levels during microabrasion of the enamel surface. There were 27 different treatment combinations of time, applications, and pressure used in this investigation. One specimen was used for each combination. An initial acid-pumice treatment was done on the right treatment section followed by a repetition of the same treatment on the left treatment section.

Analysis

One longitudinal section was cut from the center of each of the 54 treated areas and ground to a thickness of 75–90 μm using the cutting-grinding technique for histologic sectioning of hard tissues described by Rohrer and Schubert.[6] The sections were examined by polarized and normal light, and measurements were made using a Bioquant IV Image Analysis Program (R&M Biometrics Inc, Nashville, TN) with a DAGE-MTI 65 camera (Dage-MTI Inc, Michigan City, IN) attached to an Olympus BH2 compound microscope (Olympus Corp, Lake Success, NY). Most measurements were made at 40x magnification. In order to measure the maximum depth of the resultant etched groove, a line was generated extending from one side of the groove to the other. A perpendicular plumb line was dropped from that line and the maximum depth was recorded using the computer image analysis program. Fig 4 shows the line across the groove and the perpendicular line, which was used to determine the amount of enamel loss. Two individuals independently made 10 measurements of each of the 54 etched grooves. The measurements were averaged to determine the average enamel loss per groove. Variability in the measurements was extremely small.

Statistics

A two-way factorial analysis of variance (ANOVA) was applied to examine the variability of application time and number of applications under pressures of 10, 20, and 30 g. Tukey's multiple comparison was used to examine the variability between nine groups. The variables of time of application, number of applications, and pressure of the applicator on the enamel were studied individually and in combination. Three two-way factorial ANOVAs were applied under pressures of 10, 20, and 30 g. The two factors in each ANOVA were time of application and number of applications ($P < 0.05$).

Results

The results are presented in the table. This table shows the extent of enamel loss resulting from 27 different treatment combinations using 18% HCL and pumice. The results of each statistical analysis resulted in each factor being statistically significant by itself ($P < 0.05$). Tukey's multiple comparison showed further that all comparisons between the nine groups were significant, indicating that both time of application and number applications were effective in enamel removal as each factor was increased ($P < 0.05$).

As an example, the treatment combination in Group 1 under 20 g of pressure resulted in enamel loss of 111 μm. There was a significant difference ($P < 0.05$) in the depth of enamel loss (204 μm) when compared with Group 3 under the same pressure and increasing the pressure to 30 grams resulted in enamel loss of 266 μm. Fig 2 shows the results of nine treatment combinations where variables of time and applications were increased at the same time under the three pressures. Increasing both factors at the same time under the same pressure resulted in increased enamel loss and increasing the

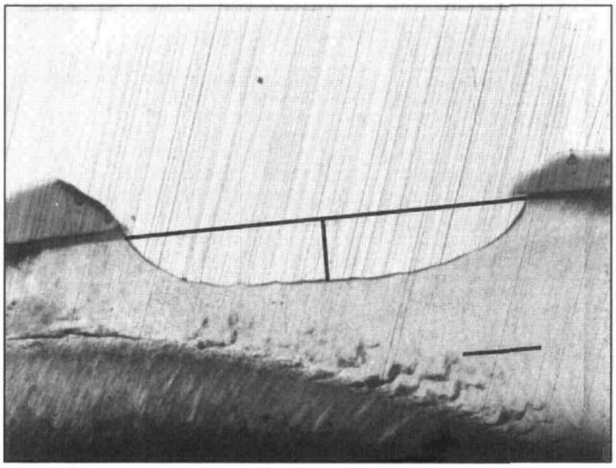

Fig 4. Low-power view showing enamel loss of 420 μm following 15 20-sec applications under 20 g pressure. A line drawn between the sides of the groove shows how the depth of abrasion was recorded (40x; bar = 500 μm).

pressure magnified the enamel loss. Fig 3 demonstrates the depth of enamel loss observed microscopically of the specimen in Group 3 under 20 g of pressure. The depth of enamel loss of the specimen in Group 9 under 20 g of pressure is shown in Fig 4.

Discussion

The microabrasion technique in this study (acid-pumice, hand applicator) was used to simulate the method commonly used in the clinical setting. This investigation used a small sample size because the method was reliable in measuring enamel loss. There were two repetitions made for each of the 27 different acid-pumice combinations, and the average variability of the 27 pairs was low (11.96 μm). This study found that enamel loss increased as each variable separately increased and when two variables increased at the same time a greater amount of enamel loss occurred. These results are difficult to compare with previous microabrasion studies[4, 5] that measured enamel loss, because although these studies used the same treatment combinations of time and number of applications, pressure was not studied. In this study applicator pressure against the tooth was an important variable by itself and in combination with time or applications on the amount of enamel removed. For example, Waggoner[4] found enamel loss of approximately 250 μm under a series of 10 five-second applications using a gentle rubbing motion. This study under the same combination of time and applications found enamel loss of 127 μm under 10 g, 178 μm under 20 g, and 213 μm under 30 g pressure.

Many successful cases of enamel microabrasion have been documented.[1–3, 9] When planning a microabrasion procedure, the clinician should be concerned with both how much enamel is lost and whether a sufficient thickness of enamel remains on the tooth for function and appearance. Since histological sections cannot be made clinically, this is not always easy to ascertain. Shillingburg and Grace[8] measured the labial enamel thickness at 1-mm intervals for the crowns of all anterior permanent teeth. The labial enamel thickness of maxillary central incisors ranged from 1.12 mm in the incisal third of the crown to 0.93 mm thickness in the middle third to 0.49 mm in the gingival third of the crown. Enamel thickness of maxillary lateral incisors was similar. Enamel thickness of mandibular incisors was less, ranging from 1.02 mm in the incisal third to 0.87 mm in the middle third to 0.36 mm thickness in the gingival third of the crown. It has been postulated[4, 10] that a 25–33% enamel reduction probably would be unrecognizable and clinically acceptable. This may be true, providing that the original enamel thickness was approximately 1 mm. Enamel loss of 300 μm or less resulted from 21 treatment combinations used in this investigation.

This study showed that increasing the pressure resulted in increased enamel loss. Croll[7] recommends light pressure be used on the hand applicator or handpiece during the microabrasion procedure. What is light pressure? The pressures used in this investigation were selected to correlate with lighter forces used by the clinician during microabrasion. Describing light pressure in words is not easy since most forces used in dentistry as well as daily living far exceed pressures of 10–30 g. A 10-g pressure is about the lightest pressure a clinician could use with a hand applicator — equivalent to the absolute weight of the plastic applicator tip resting on the enamel with only the finger pressure necessary to hold the instrument against the tooth during the rubbing action. A fountain pen held with finger pressure used in writing is another example of a 10- to 15-g pressure. Writing with a double-ended red-blue pencil can describe heavier finger pressures. Increasing the downward pressure of the blue end of a colored pencil against paper increases the color intensity from a light to a dark blue color. The light blue color from the blue pencil tip against paper would be equivalent to a 25–30 g pressure.

Different types of applicators such as orange wood sticks, sections of wooden tongue blades, and rotary rubber cups have been used in the microabrasion procedure. Enamel lost is partly governed by size or diameter of the applicator hardness of the rubber cup, and speed of the handpiece. Additional investigation regarding the type of applicator and how it is used (pressure) should be evaluated to understand the microabrasion process and develop a uniform, reliable treatment protocol.

Conclusions

1. Enamel loss increased as variables of time, number of applications, and pressure increased separately.

2. A greater amount of enamel loss occurred when two or more variables increased at the same time.

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