

Microabrasion of human enamel in vitro using hydrochloric acid and pumice

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Abstract

The rubbing application of a hydrochloric acid-pumice mixture has been advocated for the removal of fluorotic-like areas of permanent teeth. However, there have been no previous reports as to the amount of enamel removed during this process. The objective of this project was to measure the amount of enamel lost during successive rubbing applications of an 18% HCl-pumice mixture. Nine extracted permanent molars were mounted in die stone, and each was subjected to 10 sequential 5-sec rubbing applications of an 18% HCl-pumice mixture. After rubbing for 5 sec, the teeth were rinsed with water for 10 sec and then thoroughly dried. Enamel loss was measured to the nearest micron utilizing a measuring microscope with 3-dimensional digital stage positioning. Measurements were taken at the consistent x,y coordinates of three points on the tooth surface after each application. The change in the z coordinate, representing the spatial change in the location of the enamel surface, was recorded for each point after each application on the tooth. Regression analysis revealed enamel loss of 12 μm after the initial application, and an average of 26 μm of enamel loss after each successive application. The regression coefficient was significant at $P < 0.001$.

Fluorotic-like areas of discoloration on permanent incisors often create an esthetically compromised appearance. Over the years a number of techniques to remove the discoloration have been described. Hydrochloric acid (HCl) applied to the discolored areas either alone (Raper and Manser 1941; McCloskey 1984), or in a pumice mixture (McCloskey 1984; Croll and Cavanaugh 1986a, 1986b, 1986c), or with a variety of other chemicals (McInnes 1966; Murrin and Barkmeier 1982; Powell and Craig 1982) has been suggested to remove discolored areas, especially brown stain. One method, described by Croll and Cavanaugh (1986a), utilizes serial rubbing applications of a paste mixture of 18%

HCl and pumice. This causes an abrasion of enamel that removes superficial stains and defects. This technique provides significant esthetic improvement. However, little information is available regarding the amount of enamel lost as a result of these sequential applications. The purposes of the present study were 1) to develop a method to measure the amount of enamel lost by abrasion, and 2) to measure the amount of enamel lost during the successive rubbing application of a HCl-pumice mixture on human permanent teeth.

Review of Literature

A number of techniques have been described to improve the appearance of fluorotic teeth (Raper and Manser 1941; McInnes 1966; Bailey and Cristen 1968; Colon 1973; Chandra and Chawla 1975; Murrin and Barkmeier 1982; Powell and Craig 1982; Jordan and Boksman 1984; McCloskey 1984; Croll and Cavanaugh 1986a). As early as 1916, Dr. Walter Kane successfully removed fluorosis stains by applying acid and heat (McCloskey 1984). McInnes (1966) reported using 5 parts 36% HCl and 30% hydrogen peroxide, and one part ether as a topical treatment. This treatment was modified slightly by Chandra and Chawla (1975) by applying the solution with cuttle bone and sandpaper disks in a rotary instrument. However, they observed a noticeable loss in mesiodistal curvature in some teeth after the procedure. Others (Powell and Craig 1982; Myers and Lyon 1986) have reported improvement using a calcium sucrose phosphate gel to remove stain. This procedure involved etching the teeth for 2-3 min with 37% phosphoric acid followed by a pumice abrasion with rotary instrumentation of the surface. These 2 steps then were repeated and followed by a 4-min application of 2% sodium fluoride. Forty per cent calcium sucrose phosphate then was applied to the etched

tooth surface. If, in 4 weeks, significant improvement was not noted, the treatment was repeated. Murrin and Barkmeier (1982) used 36% hydrochloric acid mixed with pumice applied to the enamel surface with a slowly rotating rubber cup for up to five uninterrupted min. The teeth then were bleached with 30% hydrogen peroxide and heat application, treated with topical fluoride, and polished with abrasives.

Croll and Cavanaugh (1986a, 1986b, 1986c) have advocated a regimen of up to 15 separate 5-sec applications of 18% HCl-pumice paste followed in succession by 10-sec water rinses. Their technique is as follows. The teeth to be treated are isolated with a rubber dam sealed cervically with cavity varnish. The acid is mixed with a fine flour of pumice to make a thick paste to prevent unwanted acid flow and to provide a vehicle for pressure-induced abrasion. A sodium bicarbonate paste is applied around the isolated area on the rubber dam to help neutralize any acid which flows from the area of application. The acid-pumice mixture is applied to the facial surface of each affected tooth with a wooden stick with a gentle rubbing motion for 5 sec. The tooth then is rinsed with water for 10-15 sec and dried with compressed air. This procedure is repeated until the desired color correction is achieved. In most cases, distinct color improvement occurs by the sixth or seventh application. If no change is apparent after 12 to 15 applications, the technique is terminated to avoid excessive enamel loss. Following the final rubbing application of the paste, the enamel surface is smoothed with a rubber cup and regular pumice/water mixture, and polished with sandpaper disks. Then a 1.1% neutral sodium fluoride gel is applied for 4 min to aid in immediate remineralization of the enamel.

The amount of enamel lost from this technique is not known. Croll and Cavanaugh (1986b) state that the amount of facial enamel loss is clinically unrecognizable. Bailey and Christen (1970) measured enamel loss resulting from application of a bleaching solution of 5 parts 30% hydrogen peroxide, 5 parts 36% HCl, and 1 part ether, applied with a fine cuttle disk. Their measurements, on extracted teeth, were made utilizing a Boley gauge (accurate to 0.1 mm), and were made after the completion of all applications. After a 20-min application they found that there was approximately 0.1 mm of enamel loss. Olin, Lehner, and Hilton (1988) examined the enamel surfaces of several extracted permanent teeth with the scanning electron microscope after 10 and 20 5-sec rotary applications of HCl-pumice paste. They found that enamel was being removed both by chemical erosion and mechanical abrasion, but did not attempt to quantify the amount of enamel lost.

Methods and Materials

Three extracted permanent molars which had been stored in distilled water and thymol were used to establish the precision of repeatedly recording the location of an enamel surface. None of these teeth showed visible signs of fluorosis or any other noticeable defect or decalcification. Each tooth was mounted horizontally in a small block of improved die stone with the buccal surface exposed. Each tooth then was mounted on a measuring microscope (Leitz Optical Measuring Microscope, E. Leitz Inc., Rochleigh, NJ) for recording the location of the enamel surface (Fig 1).



Fig 1. The measuring microscope with digimatic stage positioning and microcomputer interface.

The measuring microscope is equipped with a digital indicator (Mitutoyo digimatic indicator, Mitutoyo Mfg Co Ltd, Tokyo, Japan) for each of the two horizontal directions (X and Y), which controls the position of the sample stage under the microscope. The stage is equipped with sample clamps for reproducible positioning of the sample on the stage. A third digital indicator monitors the focus position (Z axis) of the microscope above the sample stage. The three indicators are connected electrically to an interface device (Mitutoyo MUX-10 Interface Device, Mitutoyo Mfg Co Ltd, Tokyo, Japan) which permits the data to be transferred to a microcomputer for diskette recording. The microscope has a small pointer, with a radius of curvature at the tip of 0.6 mm, attached to the objective holder. This pointer can be brought to rest against the sample surface by the fine focus control.

After the tooth sample was mounted on the microscope stage with the buccal surface normal to the

pointer, three points on the enamel surface were identified (Fig 2). These three points were contained within a

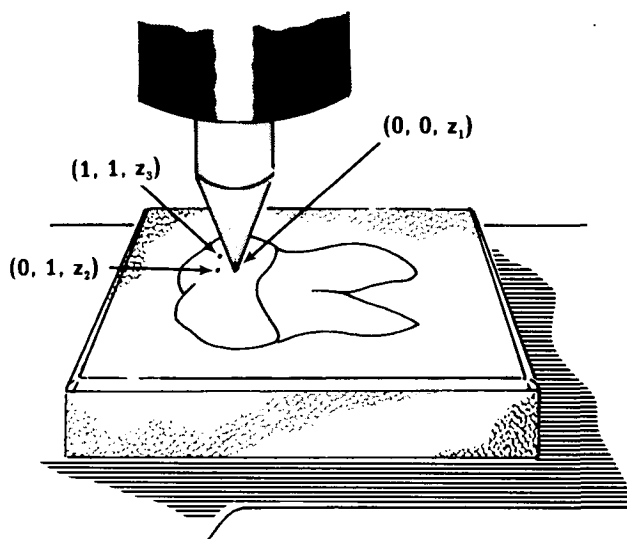


Fig 2. The buccal surface of the sample was positioned normal to the pointer of the microscope. The (x,y) coordinates of three points were identified, and the change in the z coordinate was recorded for each point after each HCl-pumice application.

relatively flat area of the enamel surface, were no further than 1.4 mm from one another, and could be consistently identified with the digimatic stage positioning. The precision of recording the position of the enamel surface was determined by recording the Z position of the microscope with the pointer in contact with the enamel surface at each of the three different points for each tooth. Each sample was removed and remounted ten consecutive times, with the value of the Z point recorded for each of the three reproducible points. Analysis of variance was used to determine the variability caused by remounting.

To measure the enamel loss resulting from abrasion with the HCl-pumice slurry, nine extracted permanent molars were selected and mounted as above. Prior to any abrasion, at each of the three points on the enamel surface, the spatial location of the enamel surface (the Z value) was recorded. Each tooth then was removed from the microscope and a slurry made of 1 ml of 18% hydrochloric acid, and 1 g of pumice (Grade CL85-medium, Whip Mix Corp., Louisville, KY, USA) was hand-rubbed onto the enamel surface for 5 sec using a wooden stick. The enamel then was rinsed with water for 10 sec and dried with compressed air. Each tooth then was remounted on the microscope, and the Z value of the enamel surface was recorded once again at each of the three points.

The effect of bringing the microscope pointer in contact with the abraded surface was evaluated by measuring the indentation left by the pointer. No inden-

tation was found in unabraded enamel, but occasionally small indentations were observed in measured surfaces after abrasion. The depth of these indentations was found to be similar, regardless of the number of abrasive applications which had been applied. The average indentation depth was found to be $2\ \mu\text{m}$. This amount was factored into the recorded Z value for the measurements taken after abrasion.

The amount of enamel loss due to abrasion was determined by first averaging the Z value for the three points on each of the nine teeth recorded after each abrasive step. The enamel position before any abrasion was identified as abrasive step 0. A regression analysis with regression diagnostics (Cook 1977, 1979) was used to determine the average change in position of the enamel surfaces and to identify any significant deviations from linearity.

Results

The analysis of variance of repeated enamel position determinations after remounting the samples, but prior to any abrasion, revealed that the pooled standard deviation of the measured Z position was $6.8\ \mu\text{m}$.

For the abraded samples, the average enamel position relative to the baseline (abrasion step 0) is shown in Fig 3. The regression analysis of this data revealed that

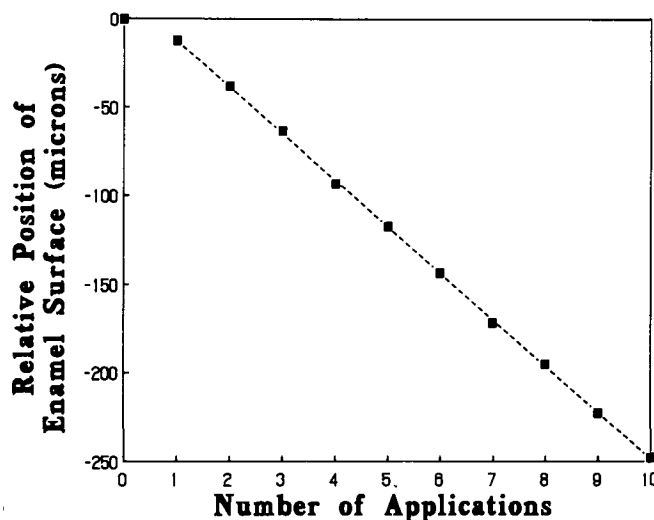


Fig 3. The average relative position and regression of the enamel surface of the nine extracted human teeth subjected to 10 HCl-pumice abrasive applications. The regression excludes the first application, because it did not conform to the linearity of the remaining abrasive applications. The relative change in the position of the enamel surface (amount of enamel lost) was $12\ \mu\text{m}$ after the first application and $26\ \mu\text{m}$ for each successive step.

abrasion from the first acid-pumice application did not conform to the linearity defined by the remaining abrasion steps, so the regression was recalculated with this

application step omitted. The amount of change from the first application was 12 μm . The subsequent regression was statistically significant at $P < 0.001$ and is illustrated in Fig 3. The regression coefficient, which for this data represents the average change in the enamel surface for each abrasion step, was 26 μm per abrasion step, with a standard error of 0.13 μm per abrasion step. The r-square value was 0.9998 for this regression.

Discussion

The use of a measuring microscope was an effective method of measuring the enamel loss. The standard deviation of location measurements associated with remounting the sample was within an acceptable range for use with this experimental design which considered the average enamel loss of nine teeth. Multiple points on each tooth were selected to be measured because the amount of enamel loss was expected not to be uniform from point to point, and the use of several points would allow for a more accurate representation of the average enamel loss to be determined. For each acid-pumice application there were 27 separate measurements made and averaged to arrive at the average loss per application.

The first application of the HCl-pumice mixture removed 12 μm of enamel; however, each subsequent application removed 26 μm . The higher degree of mineralization, fluoride, and lead content of the surface layer of enamel, which make it more resistant to acid dissolution (Silverstone et al. 1981), likely accounts for the smaller amount of enamel lost after the first application of the HCl-pumice mixture.

Thylstrup and Fejerskov (1978) have noted that the macroscopic changes, which contribute to the clinical appearance of mild fluorotic-like lesions, have been shown in ground sections to lie in the outer 80-100 μm of enamel. Several of the bleaching techniques have described successful removal of brown stain associated with fluorosis (Bailey and Christen 1968; Colon 1973; Chandra and Chawla 1975), but poorer success with the removal of white opacities which are felt to extend more deeply into enamel (Black and McKay 1916). Aasenden and Peebles (1978) have noted that opacities regarded as typical of mild fluorosis were less apparent after some years. They suggested that this reduction in mottling may have been due to mineralization or abrasion of the affected areas. Consequently, etching and polishing treatments for improving appearance of mottled teeth may merely simulate a natural abrasion process that occurs over a number of years (Powell and Craig 1982).

Croll and Cavanaugh (1986a, 1986b, 1986c) have demonstrated numerous examples of white, yellow, and multicolored defects of the enamel that were re-

moved utilizing the HCl-pumice technique. It is possible that the reason that these opacities were altered was due to the removal of more enamel than other bleaching/abrasive techniques, or some alteration in the surface which created changes in the optical properties of the enamel.

Is the amount of enamel lost by the abrasion clinically significant? It appears not. The thickness of enamel in the midlabial area of permanent incisors is approximately 1 mm (Bailey and Christen 1970). Ten applications of HCl-pumice will remove approximately 25% of that enamel. Croll and Cavanaugh (1986b) have stated that the amount is clinically unrecognizable. Bailey and Christen (1970) reported enamel loss of 100 μm following the use of a solution of 30% hydrogen peroxide, 18% HCl, and ether. However, they concluded that even if a technique removed as much as one third of the enamel surface in a localized affected area, that would be within a clinically acceptable range.

The present study utilized intact, nonfluorosed teeth. It might be postulated that a fluorosed tooth would be more resistant to acid dissolution and, therefore, have a lesser amount of enamel loss than nonfluorosed teeth; however, in the study by Bailey and Christen (1970) half of their specimens demonstrated endemic dental fluorosis, and the other half demonstrated no fluorotic-like areas. They found no difference in the amount of enamel lost based on presence of fluorosis.

Conclusions

The serial rubbing application of a mixture of 18% HCl and pumice initially removes an average of 12 μm of enamel, with 26 μm removed with each subsequent application. A series of 10 applications will remove enough enamel to account for approximately 25% of the labial enamel of a permanent incisor.

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Smokeless tobacco risks told

More than half the professional baseball players surveyed by the University of California at San Francisco use or have used smokeless tobacco. Nearly half of those were found to have oral lesions.

Samples of tissue taken from some of the lesions showed they were not cancerous, but some are likely to develop into cancer, according to a researcher at the university.

The researchers found that among those who had used smokeless tobacco at least weekly, 46% had oral lesions. Less than 2% of nonusers had such lesions.

Long-term use of smokeless tobacco, which increases the risk of cancer of the mouth, also increases the likelihood of high blood pressure, heart disease, ulcers, and cancer of the digestive system, according to the researchers. They added that smokeless tobacco users absorb more than twice as much nicotine as cigarette smokers.

Ballplayers were chosen for the study because so many of them use smokeless tobacco and because they serve as role models for young people. Most of the tobacco-using ballplayers preferred snuff to chewing tobacco, and snuff produced more lesions than chewing tobacco.

During the study, some of the players stopped using smokeless tobacco because they were scared. Lesions disappeared in some of those who quit.

Major league teams participating in the survey included the Chicago Cubs, San Francisco Giants, Oakland Athletics, California Angels, Cleveland Indians, Seattle Mariners, and Milwaukee Brewers.