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Acid Etching Patterns on Buccal Surfaces of Permanent Teeth

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Abstract

Retention difficulties have been encountered when brackets are bonded to buccal tooth surfaces with resin. Crucial to these procedures is the quality of the enamel etch. The purpose of this study was to investigate acid etching patterns on the buccal surfaces of human posterior teeth, and to determine if mechanical pretreatment affects acid etching patterns. One hundred human posterior teeth were prepared for study. The crowns were pumiced, sectioned mesiodistally with a Gillings and Bronwell sectioning machine, washed, and dried. The buccal surfaces were etched for either 60 or 90 seconds with five different acids. An additional 25 specimens were pretreated mechanically, prepared similarly, and were etched for 90 seconds. Using standard techniques, specimens were examined with the scanning electron microscope. Regardless of etching time or acid type, 5 distinct etching patterns were observed with a recognizable geographic distribution. Types 1, 2 and 3 etch patterns paralleled the findings of Silverstone et al., but were mainly found in the coronal and middle thirds of the buccal surfaces. Types 4 and 5 etch patterns, which were porous and smooth respectively, were mainly located in the cervical third of the buccal surfaces. Mechanical pretreatment by grinding produced a more favorable etch pattern.

Introduction

Retention of dental resin materials is enhanced greatly by pretreatment of the enamel surfaces with certain inorganic acids or chelators.[1] The acid solutions act by partially decalcifying the enamel, creating microirregularities on the surface of the teeth. The procedure, referred to as acid etching, has received much attention from investigators, since the quality of the acid etch is a crucial factor in the retention of materials.

Silverstone *et al.*[2] recently described and classified three types of etching patterns. Type 1 had enamel prism cores preferentially removed. Type 2 was the reverse pattern where the peripheral regions of the prisms were removed leaving relatively unaffected prism cores. Type 3 had areas corresponding to both Types 1 and 2. These observations were made using smooth surface and occlusal surface tooth areas.

The present study was initiated to determine which acid treatments would yield the most consistently favorable etching patterns on buccal tooth surfaces. Preliminary observations, however, revealed a deficiency in the current classification of etching patterns. Accordingly, the purpose of this paper is to describe etching patterns on the buccal enamel surfaces of human teeth which were acid preconditioned and examined with scanning electron microscopy. Failures have been encountered when direct bonding brackets are wired to buccal surfaces.[3,4] Therefore, a second aim of the study was to determine if mechanical pretreatment (light grinding) of buccal surfaces modifies etching patterns.

Methods and Materials

To investigate buccal surface etching patterns, 100 human premolar and molar permanent teeth were collected and stored in formalin at −4°C. Specimens were prepared by lightly polishing the crowns of the teeth with pumice and a soft bristle brush. Teeth were sectioned at the cemento-enamel junction using a Gillings and Bronwell sectioning machine, and the roots were discarded. The crowns of the teeth were cut on a mesiodistal line and the buccal surfaces were retained for experiments. The buccal surfaces were washed thoroughly in water and dried. Specimens were acid etched individually for 60 or 90 seconds using a sable brush (00). The five acids used were (a) 37% phosphoric acid,* (b) 50% phosphoric acid,** (c)

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* (a) Concise-brand Orthokit—3M
** (b) Caulk Solo Tach—L. D. Caulk

50% phosphoric acid,† (d) 50% phosphoric acid buffered with 7% zinc oxide by weight,†† and (e) a 30% phosphoric acid (W/W) solution prepared in the laboratory. All etched surfaces were carefully rinsed with water and dried with a clean air spray free from oil contamination.

The study surfaces were mounted to aluminum stubs and a 200 A layer of gold palladium was evaporated onto the enamel surface to prevent a charge build-up on the specimen during electron bombardment. Following preparation, specimens were examined with an Hitachi HHS 2R scanning electron microscope which was operated on an accelerating potential of 20 k.v. All specimens were scanned on the buccal surfaces from occlusal to the cemento-enamel areas.

Using an additional 25 permanent teeth consisting of 10 molars, 10 premolars and five incisors, the effects of grinding on buccal surfaces were studied. Specimens were prepared in the manner previously described. The right side of each buccal surface was lightly ground with a green stone. In the initial stages of the experiment, the ground and unground sections were divided by a line of nail polish. This demarcation was found to be unnecessary, and was deleted as the study progressed. For this portion of the experiment, etching was accomplished using 37% (W/W) H_3PO_4 solution applied for 90 seconds.

Results

Five acids and two etching times were used to examine etching patterns. Each of the 10 study groups contained 10 specimens; a realistic sample size when considering the variable enamel quality between teeth and between areas of the same tooth. Regardless of the types of acid used, the 90-second acid application yielded the most *consistently* favorable etch. The 60-second etching time allowed identification of the etching patterns; however, these specimens contained more area of unetched enamel.

Five etching patterns were distinguished on the buccal surfaces. Figure 1 shows a typical Type 1 etching pattern where prism cores were preferentially removed, leaving prism peripheries intact. The Type 2 etching pattern is shown in Figure 2: the prism cores remain relatively intact while the prism peripheries are demineralized selectively. Figure 3 exhibits a Type 3 etching pattern, which is a mixture of Type 1 and Type 2 configurations. A pitted enamel surface has been classified as a Type 4 pattern, and is shown in Figure 4. A Type 5 pattern is characterized in Figure 5, which has a flat, smooth surface after etching. The etching patterns were observed in all acid groups after either 60 or 90 seconds of acid application.

An interesting finding was the distribution of the etching patterns shown in Table 1. Type 1 and Type 2 etches predominated on the coronal areas of the buccal surfaces. The Type 3 etch, a combination of Types 1 and 2, was primarily located in the middle third. The Type 4 and 5 etches, which were less well defined patterns, were observed mostly in the cervical regions of the buccal surfaces.

The study sample contained some bicuspids removed for orthodontic purposes. It was observed that these younger teeth which often contained perikymata and imbrication lines displayed a slightly different etching pattern on the cervical regions. It was observed that the perikymata had a Type 1 pattern and appeared to etch better than the imbrication lines, which exhibited a Type 4 pattern.

The mechanical pretreatment portion of the study revealed that grinding the enamel surface enhanced the quality of the etch, (see Figure 6). Using higher magnification, the enamel surfaces displayed uniform Type 1 and 2 etching patterns over entire ground areas. Moreover, regions which etched as Type 4 or 5 on the unground left side demonstrated only Type 1 and 2 patterns on the ground right side.

The amount of enamel removed by grinding was measured in the range of 140-150 μm. At the ground-unground enamel junction, where grinding was shallower and less uniform, the etching lacked uniformity. In these areas patches of Type 4 and 5 etch patterns were evident.

Discussion

A significant finding of this study is the observation and description of 2 types of etching patterns not included in existing classifications. They were present to varying extents in all specimens examined, *regardless of the acid treatment.* Although the two patterns referred to as Types 4 and 5 have been observed in the past, they appeared to have a random distribution and little importance was accorded to them. This study found them to have a more systematic distribution. Consequently, when examining etching patterns of buccal surface enamel, their existence merits consideration by both researchers and clinicians.

It has been traditional for the properties of prism cores and peripheries following acid treatment to provide the basis for classification of etching patterns. This is the basis of classification of Silverstone *et al.*[2] Types 1, 2 and 3 etching patterns are classified this

† (c) Caulk Auto Tach—L. D. Caulk
†† (d) Caulk Nuva System for orthodontic brackets—L. D. Caulk

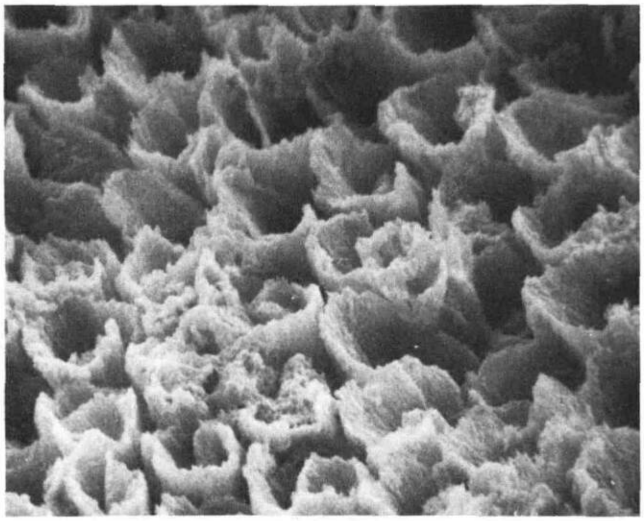

Figure 1. Scanning electron micrograph showing Type 1 etching pattern after applying phosphoric acid for 1 minute. (Magnification X 1750).

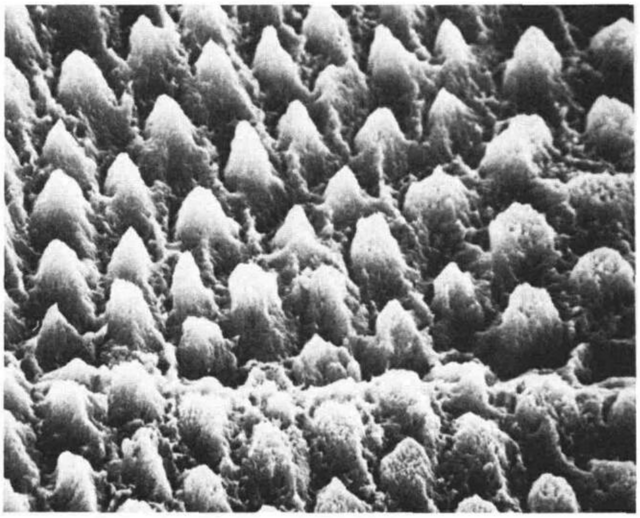

Figure 3. Scanning electron micrograph showing Type 3 etching pattern after applying phosphoric acid for 1 minute. (Magnification X 1750).

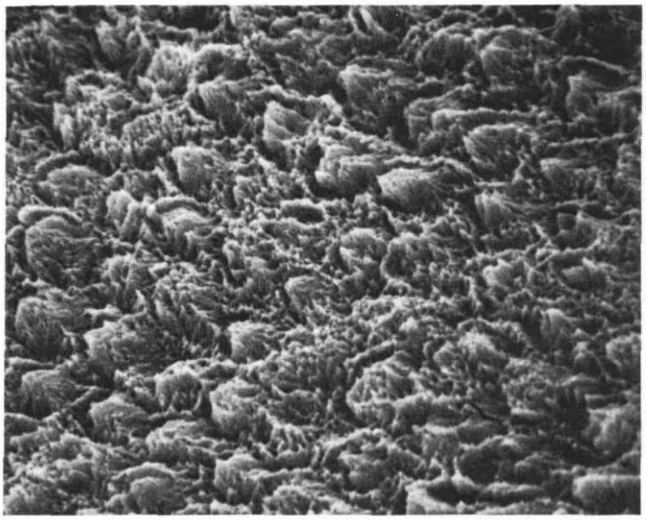

Figure 2. Scanning electron micrograph showing Type 2 etching pattern after applying phosphoric acid for 1 minute. (Magnification X 1750).

Figure 4. Scanning electron micrograph showing Type 4 etching pattern after applying phosphoric acid for 1 minute. (Magnification X 1750).

way and are in agreement with previous observations. The Type 4 pattern differed. It displayed only a random distribution of depressions with no preferential destruction of either cores or peripheries. These pitted areas occasionally occurred in little patches over the enamel surface. As shown in Table 1, Type 4 etching was commonly found in the cervical areas and has a diminished frequency in the occlusal areas.

It is difficult to account for the findings of the Type 4 etch pattern. The distribution suggests an underlying difference in enamel morphology. Ripa *et al.* found a layer of prismless enamel on 70% of the permanent teeth they scanned.[5] Gwinnett[6] demonstrated that etched prismless enamel displays no rod or prism patterns. It is similar to the Type 4 etch pattern. Therefore, it is plausible that Type 4 etching may result when regions of prismless enamel are present.

It is important to point out that most investigators are in agreement on the presence of prismless enamel, but they differ in opinion on its frequency and location.[7-11] These studies were not limited to studying the buccal surfaces of human posterior teeth. It could

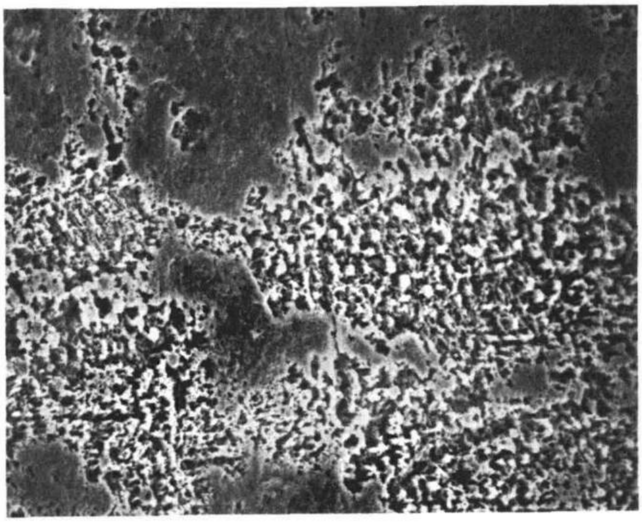

Figure 5. Scanning electron micrograph showing Type 5 etching pattern after applying phosphoric acid for 1 minute. (Magnification X 1750).

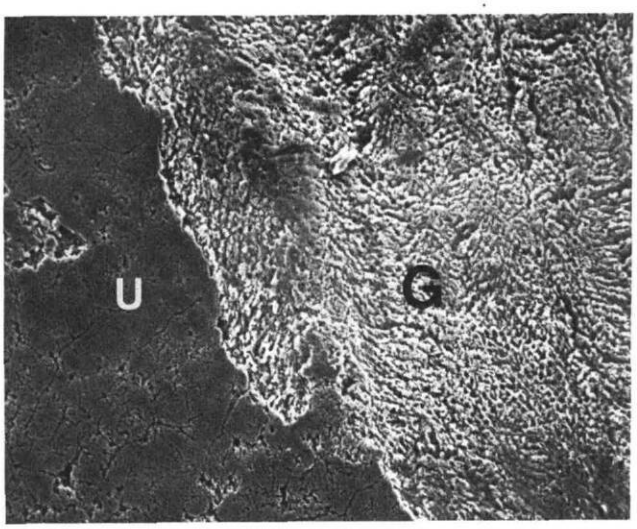

Figure 6. Scanning electron micrograph (low mag.) illustrating the difference between ground enamel (G) on the right side and unground enamel (U) on the left side. 90 second etching with phosphoric acid. (Magnification X 300).

TABLE 1. Distribution of Etching Types on the Buccal Surfaces

Types of Etch Pattern	% Frequency of Observation — *Location* Coronal	Middle	Cervical
1	75	20	5
2	75	20	5
3	10	80	10
4	5	20	75
5	5	20	75

be fallacious to extrapolate findings from one tooth area to another.

Similar to Type 4 patterns, Type 5 etching shows no evidence of prism outlines. Indeed, the regions of enamel classified as Type 5 are extremely flat and smooth, and they lack microirregularities for penetration and retention of resins. The same type of pattern was noted by Wei in a S.E.M. study of acid etching on fluoride treated teeth.[12] Therefore, it is possible that Type 5 etching patterns occur on teeth which have previously received fluoride treatment or possibly from patients who resided in high fluoride areas. The finding could account for the retention problems encountered when clinicians attempt to etch and seal fluoride treated teeth. However, a Type 5 pattern would be expected over the entire enamel surface if fluoridation were responsible, and this study found only a scattered distribution of Type 5 areas in the occlusal region. Obviously, chemical analysis of teeth subject to Type 5 etching is required to resolve this question.

Although the underlying causes of Types 4 and 5 etching remain academically debatable, these etching patterns do exist. They may be responsible for some retention problems encountered in research and clinical practice. For these reasons, the authors of this paper consider it essential that Type 4 and 5 etch patterns be included in future etch classifications.

The photomicrographs of the mechanically pretreated specimens showed that removal of a thin layer of surface enamel leads to more consistently superior etching patterns for primary and permanent teeth. It is suggested that grinding removes superficial areas of prismless enamel, thus exposing underlying prismatic enamel that is more prone to acid etching.

The mechanical pretreatment effects differed from those of Brannstrom *et al.* who found little change when grinding with a diamond point or aluminum oxide disc.[13] These authors, however, had not indicated the amount of superficial enamel removed. In the present study, the most consistently favorable etches were seen when 140 to 150 μm of enamel were removed. The transitional areas, which had shallower and uneven grinding, had less uniform etch patterns. Apparently, the amount of "buccal correction" necessary for optimum etching, particularly in the cervical region of buccal surfaces, should be established in future studies.

Conclusions

This study examined the acid etching effects on the buccal surfaces of human posterior teeth with scanning electron microscopy. Based on the findings of this investigation, it was concluded that five etching patterns are present on the buccal surfaces of human posterior teeth; the etching patterns appear to have a systematic geographic distribution; and mechanical pretreatment by grinding enhances etching patterns on buccal surface enamel.

Acknowledgments

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