

Comparative Study of the Effect of Acid Etching on Enamel Surface Roughness between Pumiced and Non-pumiced Teeth

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Abstract:

Background: The objective was to perform a comparative analysis of the effect of acid etching on enamel roughness between pumiced and non-pumiced teeth.

Materials and Methods: The sample was composed of 32 dental surfaces divided into two groups: Group 1-16 surfaces having received pumice prophylaxis; and Group 2-16 surfaces not having received pumice prophylaxis. The teeth were kept in saline until the first record of surface roughness prior to etching. For each surface, a roughness graph was obtained through trials using a surface roughness tester. This procedure was repeated two more times at different locations for a total of three readings which, later, were converted in a mean value. The teeth were then acid etched with a 37% phosphoric acid for 60 s, rinsed with water, air dried, and tested with the roughness tester again using the same protocol described for baseline. The Quantikov image analysis program was used to measure the length of the graphs. The average value of the lengths was recorded for each surface before and after etching. The increase in roughness caused by acid etching was calculated and compared between groups.

Results: The mean increase in roughness caused by the etching was 301 μm (11.37%) in Group 1 and 214 μm (8.33%) in Group 2. No statistically significant difference was found between samples with and without pumice prophylaxis ($P = 0.283$).

Conclusion: The present study showed that the effect of acid etching on enamel roughness was not significantly affected by prior pumice prophylaxis.

Key Words: Dental acid etching, dental bonding, dental enamel

Introduction

Orthodontic research is constantly seeking to improve and optimize the technique of bonding brackets to enamel. The strength of the bond between the bracket and the enamel surface depends on the retention mechanism of the bracket base, the adhesive material or bonding resin, and the preparation of the tooth surface.^{1,2} Orthodontic treatment with fixed appliances requires clinicians to bond the brackets properly to the enamel surfaces of the teeth. Bond failures result in professional and patient inconvenience, increasing both "chair time" per appointment and the duration of treatment. Bonding in orthodontics is based on a three-step process of preparing the enamel surface with a 37% phosphoric acid etchant, followed by a priming agent and adhesive resin. This process can be preceded by enamel prophylaxis, which is usually performed with a rubber cup and flour of pumice.³

The elimination of one or more steps in the bracket bonding process without compromising clinical reliability has been the aim of research in adhesive dentistry. One of these steps is the preparation of the enamel surface by removing the acquired pellicle using pumice prophylaxis prior to acid etching.⁴ Much attention has been given to this issue. Some studies have presented contrasting results when the need to carry out pumice prophylaxis before acid etching for bracket bonding is evaluated.⁵ Therefore, no consensus in the literature has been reached thus far.¹

Surface roughness is one of the most frequently used test methods to evaluate the effect of acid etching after prophylactic techniques on dental hard tissues^{6,7} and is well accepted as a comparative feature, quantifying surface texture by means of randomized amplitudes readings.⁸ Moreover, roughness, similarly to hardness,⁹ is an important property of teeth, as it can affect the mechanical attachment of foreign materials on their surfaces. Among several parameters used to measure surface roughness, the average surface roughness (Ra) is more commonly reported within dental studies.^{10,11} To the best of our knowledge, no prior investigation has compared the effect of acid etching on enamel roughness between teeth with and without pumice prophylaxis. Thus, the purpose of the present study was to perform a comparative analysis of the effect of acid etching for bracket bonding on the enamel surface roughness between pumiced and non-pumiced teeth.

Materials and Methods

Sample and eligibility criteria

The present study used a convenience sample of teeth extracted for orthodontic reasons. Only participants with the extraction of two or four pre-molars were selected for this study. Pairs of samples (with and without pumice prophylaxis) were obtained from the same participant. Teeth were selected only if they had intact vestibular and lingual enamel. Filled pre-molars, pre-molars with surface cracks provoked by the extraction forceps, and individuals with enamel hypoplasia, including fluorosis, were excluded from the study.

Ethical issues

Ethical approval was obtained from the Human Research Ethics Committee of the Universidade Federal de Minas Gerais under protocol number 12108. All individuals participated voluntarily and signed a statement of informed consent. Prior to acceptance, individuals were informed that if they chose not to participate, their decision would not have any consequence and would not affect the services that they were about to receive at the university in any way.

Data collection

Sixteen pre-molars were collected and maintained in saline solution. Teeth were randomly divided into two groups. The vestibular and lingual surfaces of teeth were used and, therefore, 32 tooth surfaces were included in the present study. Group 1 consisted of 16 tooth surfaces that had previously received pumice prophylaxis with a rubber cup. The water/powder proportion of the paste was standardized to obtain a firm consistency so as not to allow the dispersion of the material on the surface during application. Pumice particle size used was medium. Prophylaxis was performed by the same operator for 20 s with pressure resulting from the handpiece weight. Group 2 consisted of 16 tooth surfaces had not undergone this procedure. After eliminating all root soft tissue remnants and other extraneous material, the teeth were maintained in saline solution until the first reading of surface roughness. The tests were carried out shortly after the surgical procedure. Therefore, tooth extractions were scheduled accordingly. For each surface, a roughness graph was obtained through trials using a surface roughness tester (Talysurf 10[®], Rank Taylor Hobson, Leicester, UK). This procedure was repeated two more times at different locations for a total of three successive randomized readings that were later converted into a mean value. The position of the teeth was standardized in the roughness tester so that measurements after acid etching could be taken at the same site on tooth surfaces. The roughness tester contains two separate units: a transverse unit and an amplifier-recorder. The transverse unit includes electric drive motors to traverse the pick-up at selected speeds across the workpiece. A system of mechanical and electrical interlocks ensures that the beginning of the reading is synchronized with the traversing of the stylus across the workpiece. The amplifier-recorder contains all

the electronic circuitry and produces a graph on a chart with rectilinear coordinates; marking is achieved by electrical action on electro-sensitive charts (Figure 1).

The teeth were then acid etched with a 37% phosphoric acid (Dental Gel[®], Petrópolis, Brazil) for 60 s, rinsed with water, air dried, and again tested with the roughness tester. Final roughness was determined according to initial measurement protocol as described for the baseline. Thus, six graphs printed on electro-sensitive paper were obtained for each surface. Three graphs from three different measurements corresponded to the roughness before acid etching (Figure 2), and three graphs from three different measurements corresponded to roughness after etching (Figure 3). The Quantikov image analysis program (Quantikov[®], Belo Horizonte, Brazil)¹² was used to measure the length of the graphs obtained (Figures 4 and 5). The average value of the lengths was recorded as Ra for each surface before and after etching. The Ra is the arithmetic mean of all absolute distances of the surface roughness from the center line within the measured length.¹³ The increase in Ra caused by acid etching was then calculated and compared between groups.

Data analysis

Statistical analysis was performed using the Minitab 14 program (Minitab Inc[®], Pennsylvania, USA). Data analysis included the Shapiro–Wilk test to evaluate the assumption of normality, which was confirmed. The paired *t*-test was used to determine statistical differences in the increase in roughness between groups. The level of significance was set at 5% ($P < 0.05$).

Results

The results of the measures obtained for Groups 1 and 2 are summarized in Table 1. The mean increase in roughness was



Figure 1: Roughness tester, Talysurf 10, Rank Taylor Hobson.

Table 1: Results of increase in enamel roughness.

Groups	Mean increase in roughness (μm)	Standard deviation
Group 1	301	281
Group 2	214	183
P value	0.283	

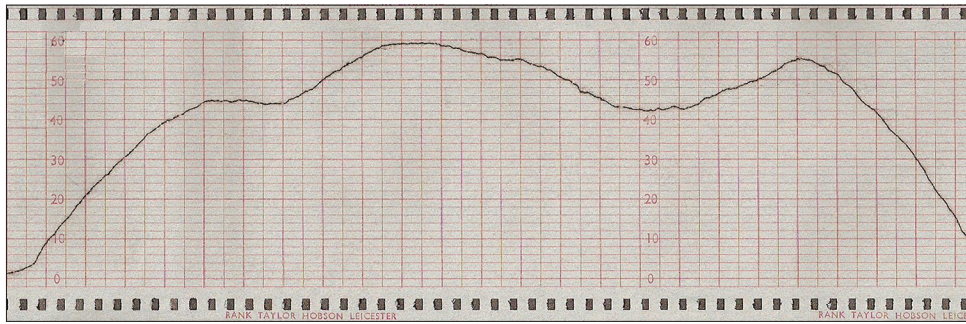


Figure 2: Enamel roughness before acid etching.

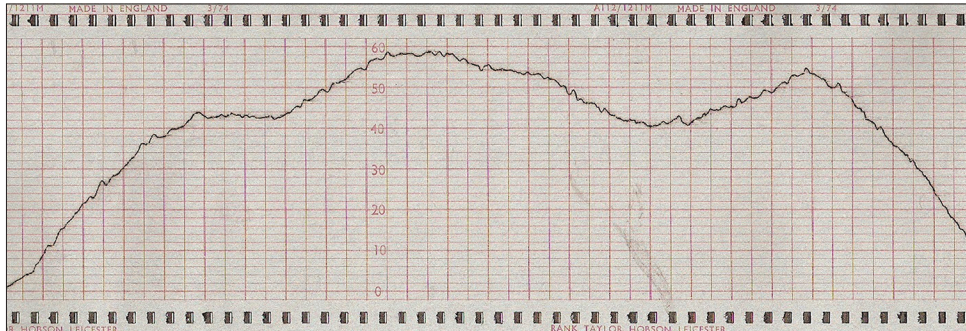


Figure 3: Enamel roughness after acid etching.

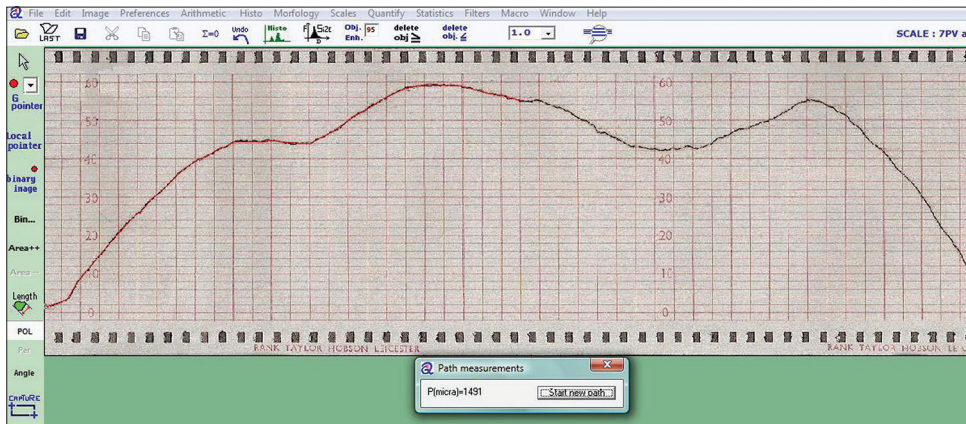


Figure 4: Quantikv measurement of enamel roughness before acid etching.

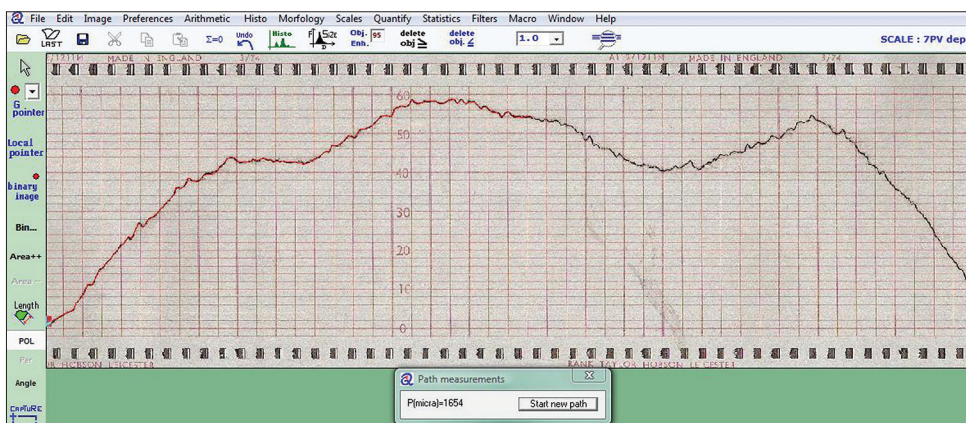


Figure 5: Quantikv measurement of enamel roughness after acid etching.

301 μm (11.37%) in Group 1 and 214 μm (8.33%) in Group 2. No statistically significant difference was found in the increase

in enamel roughness caused by acid etching between samples with and without pumice prophylaxis ($P = 0.283$).

Discussion

Since the direct bonding of orthodontic brackets became popular, pumice prophylaxis prior to the acid etching of dental enamel has been recommended to achieve a proper tooth-resin bond.³ However, some clinicians have refused to pumice the tooth enamel before bracket bonding. Concerns regarding the use of pumice include the time required to individually pumice each tooth and remove the paste, the possible introduction of gingival crevicular fluid proteins onto the enamel surface and the potential for mechanical injury to the gingival.¹⁴ Moreover, during the procedure, teeth with erosion, abrasion, abfraction lesion or restorations can also be polished inadvertently.¹⁵

The enamel surface presents a natural roughness due to the presence of Retzius grooves, pits and small defects, as well as mineral deposits that can occur in the oral environment. The present study sought to determine whether acid etching has any different effect on enamel roughness between teeth with and without prior pumice prophylaxis. To achieve this, similar to a previous study with scanning electron microscopy (SEM),⁵ a 60 s etching time was used. Many studies addressing the efficacy of orthodontic bracket bonding recommend a 15 s etching time. However, for acceptable bonding, this time may be between 15 and 60 s, with no significant difference in enamel etch patterns.¹⁶

The results of the present study reveal that the increase in enamel roughness caused by acid etching was slightly higher in the group of teeth that received pumice prophylaxis, but the difference between groups did not achieve statistical significance. Conflicting results have been reported in clinical performance studies. Previous studies on the effect of enamel pumicing prior to acid etching and bonding found that pumice prophylaxis had little effect on bond strengths and bracket attachment failure rates.^{5,17} No statistical significant difference was found for pumiced and non-pumiced samples when bond strengths⁵ and bracket retention^{5,17} were evaluated. By contrast, in a comparative evaluation of the retention of metallic brackets, the group of teeth, which were first cleaned with pumice and then acid etched, showed the lowest bond failure rate.¹ In another study that aimed to examine the surfaces characteristics of teeth that had been etched with and without prior pumice prophylaxis, SEM observations confirmed that plaque or pellicle remained on the teeth in the non-pumiced sample in some areas after etching. In addition, scratches were observed on pumiced teeth, which left the surfaces uneven.⁵ The presence of organic debris covering the enamel surface hinders the complete etching of enamel, preventing the creation of a uniform pattern of demineralization.¹⁸ However, the complex structure of a surface cannot be entirely characterized by a SEM evaluation. Complementary predictions can be made with surface roughness measurements¹⁹ which was the aim of this study.

The present study has some strengths that should be addressed. Roughness is well accepted as a comparative feature. Basically, it quantifies surface texture by means of randomized readings of the amplitudes, established as Ra. The Ra parameter is defined as the arithmetical mean of the absolute values of all roughness profile deviations from the centerline within the measured length.¹¹ The surface roughness can be measured by contact and non-contact methods. Non-contact methods use a light beam, or a laser beam, to obtain a surface profile. These techniques have the advantages of being non-damaging and performing scans within shorter times. However, one important limitation of these methods is that surfaces are sometimes difficult to measure due to the scattering effect of the reflected light. Thus, results can be affected by color and transparency, and this can lead to the documentation of false values.²⁰ The surface roughness can also be measured by contact stylus surface profilometry (SSP)²¹ or by using a roughness tester,²² as was used in the present study (Talysurf 10⁷). It can be argued that the benefit of the profilometry is the high vertical resolution given by an advanced computerized SSP. This occurs especially when measuring low roughness values. Nevertheless, the SSP is limited by the size of the stylus tip as well as by the difficulties of the technique.²³

This study also has weaknesses that should be recognized. Firstly, in spite of being widely used in both dentistry and engineering, the roughness parameter is limited by a two-dimensional aspect with no information about the entire surface profile. The way in which this is reported can lead to a misinterpretation of surface features. However, it is clear that change in tooth surfaces is a complex process that can be assessed in many ways. No technique allows for the comprehensive evaluation of a tooth surface, and each technique has its own limitations.^{10,24} The second flaw is the use of a convenience sample of individuals attending an orthodontic clinic. The most obvious criticism about a convenience sample is its lack of representativeness as well as the questionable degree of generalizability. However, studies that use convenience samples are often preliminary evaluations, which can be considered as a great source of rich comments, which in turn inspires further investigation on a specific issue.

The present results are useful for orthodontic clinical practice. Efficient orthodontic therapy with a fixed appliance requires the quick and adequate bonding of brackets to the tooth surfaces. The reduction of operative procedures, such as pumice prophylaxis improves the efficiency in clinical performance by simplifying and minimizing the complexity of the technique.^{25,26} Not only should the bonding process be less time-consuming, the reduction of a step should also entail fewer errors during the bracket bonding.²⁷ Moreover, scratches observed on pumiced teeth leave loose dentin on the root surface and pumice particles embedded in the dentin. Both of these factors can affect adhesion on tooth surfaces.¹⁵ This information can be helpful for orthodontists who perform comprehensive

orthodontic treatment as well as general dentists and pediatric dentists who are able to conduct interceptive orthodontics using preventive appliances, such as a 2 × 4 appliance.²⁸

Pumice polishing is considered a conventional and standard method of preparing enamel surface before bonding. Nevertheless, the results of the present study showed that the effect of acid etching on enamel surface roughness was similar in pumiced and non-pumiced samples. This investigation was an *in vitro* study and the different oral conditions may affect the results.²⁹ Surface roughness *in vitro* may be different when compared to the dynamic system in the oral cavity *in vivo*. Therefore, direct extrapolations to clinical conditions must be exercised with caution.³⁰ Further studies are required to determine the clinical viability of the existing pre-bonding enamel surface preparation techniques.³¹

Conclusion

Conflicting results exist concerning the need for enamel preparation with pumice before acid etching for bracket bonding. The present study showed that the effect of acid etching on enamel roughness was not significantly affected by prior pumice prophylaxis.

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