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Effects of sandblasting before orthophosphoric acid etching on lingual enamel: In-vitro roughness assessment

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Introduction: In this study, we evaluated changes in lingual enamel roughness due to sandblasting with 27-, 50-, and 90-μm aluminum oxide particles followed by 37% orthophosphoric acid etching. **Methods:** Twenty-four maxillary premolars were included in the study. The lingual enamel roughness of 20 teeth was evaluated using a laser confocal microscope before and after enamel conditioning. Group 1 (control) was etched with 37% orthophosphoric acid; groups 2, 3, and 4 were sandblasted with 27-, 50-, and 90-μm aluminum oxide particles, respectively, before acid etching. The lingual surfaces of the other 4 teeth were evaluated using scanning electron microscopy after they had received one of the conditioning methods under study. Paired *t* tests were used to compare the roughness parameters obtained before and after conditioning in each group, and 1-way analysis of variance was used to compare the surface roughness between groups. The significance level was set at 5% for all statistical analyses. **Results:** The 4 conditioning methods significantly increased the roughness of the lingual enamel. However, the roughness increases in the groups that were sandblasted with 27-, 50-, and 90-μm aluminum oxide particles before orthophosphoric acid etching were statistically greater than was the increase in the group conditioned only with orthophosphoric acid. Scanning electron microscopy showed different conditioning patterns among specimens that were conditioned only with orthophosphoric acid and those sandblasted with aluminum oxide before acid etching. **Conclusions:** Lingual enamel conditioning with aluminum oxide sandblasting before acid etching results in greater roughness and produces a conditioning pattern different from that of acid etching alone. (Am J Orthod Dentofacial Orthop 2015;147:S76-81)

Enamel etching with orthophosphoric acid was first used by Buonocore[1] in 1955. Since then, the concept of adherence of resin to enamel has developed, and the use of acid has spread to all areas of dentistry, including orthodontics. In 1965, Newman[2] proposed the use of acid etching as a means to bond brackets directly onto teeth.

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Orthophosphoric acid etching is currently the technique most often used to prepare enamel surfaces before bracket bonding.[3-7] Bracket bond strength is believed to depend on the quality and the quantity of enamel etching produced by the acid.[3] Several studies have defined the ideal concentration of orthophosphoric acid and the ideal application time to achieve effective bond strength and minimal enamel loss.[1,8-11] However, to obtain better bond strengths and to preserve the integrity of enamel, other methods to prepare enamel surface have been suggested: different acids,[12-14] high-power laser irradiation,[7,15] self-etching primers,[7,16,17] and sandblasting with aluminum oxide particles.[5,7,15,16,18-22]

Several studies have investigated the effect of enamel sandblasting with aluminum oxide particles before orthophosphoric acid etching on bracket bond strength.[3,6,7,21-23] However, little or no attention has been paid to the characteristics of the conditioned enamel surface. Enamel conditioning is a fundamental step to achieve good bracket adherence.[19] Therefore, the morphologic evaluation of conditioned enamel is important for the analysis and improvement of adhesive systems.[24] Moreover, sandblasting protocols used in studies often differ in particle size, time, distance, and pressure of application.[3,6,7,21-23]

Recently, lingual orthodontics has increasingly been requested when esthetic preservation is fundamental during orthodontic treatment. Several authors have recommended sandblasting before orthophosphoric acid etching to increase the bond strength of brackets or the fixed retention on the lingual surfaces.[25-28] However, most studies have used the buccal surfaces of extracted teeth to evaluate this type of conditioning.[6,7,21,25,29]

Studies related to sandblasting combined with orthophosphoric acid etching have used different sizes of aluminum oxide particles,[3,6,7,21-23,25,29-31] and few studies in the literature have evaluated the effects of this type of conditioning on enamel.[3,7,21,31] Additionally, our literature review did not yield any study that examined quantitative and qualitative enamel changes on lingual surfaces; hence, in this study, we evaluated changes in lingual enamel roughness after enamel conditioning using sandblasting with 27-, 50-, and 90-μm aluminum oxide particles combined with 37% orthophosphoric acid etching. The null hypothesis was that there is no significant difference in lingual enamel roughness changes after the 4 conditioning methods.

MATERIAL AND METHODS

Twenty-four maxillary premolars extracted for orthodontic reasons were obtained and stored in distilled water at room temperature until the experiment. The maximum storage period of the teeth was 1 month, and the water was changed weekly to prevent bacterial growth. All teeth were free of caries, wear, fractures, or other visible defects. This study was approved by the ethics in research committee of the University of São Paulo in Brazil (protocol # 51/11 CAAE 0057.0.017.000-11).

Enamel roughness was evaluated. Twenty teeth were embedded in type IV dental plaster (Durone; Dentsply, Petrópolis, Rio de Janeiro, Brazil) in rectangular plastic molds, so that the lingual surfaces were fully exposed and parallel to the mold bases. The lingual surfaces were cleaned with a rubber cup and pumice for 10 seconds, rinsed with water for 10 seconds, and dried with oil-free compressed air. Lingual enamel roughness was assessed at 2 times—before enamel conditioning (T1) and after enamel conditioning (T2)—using a confocal laser microscope (Leica DCM 3D; Sensofar-Tech, Terrassa, Spain). After the teeth were cleaned, images of an area (636.61 × 477.25 μm) in the center of the lingual surface of each specimen were captured with the 10-times objective lens of the confocal laser microscope. The location of the area evaluated at T1 was defined according to x- and y-coordinates, which were stored to reproduce the readings in the same area at T2.

The parameters analyzed were the average roughness (Ra) and the maximum height of the roughness profile (Rz). Roughness parameters were measured in micrometers (μm) using the software Leica Map DCM 3D to evaluate 5 horizontal and 5 vertical lines, for a total of 10 lines for each area. The values of the 10 lines were averaged to obtain the mean values of Ra and Rz for each tooth at T1.

The specimens evaluated at T1 were randomly assigned to 1 of 4 groups ($n = 5$), and a different enamel conditioning protocol of the lingual surfaces was used for each group. In group 1 (control), 37% orthophosphoric acid (Email Preparator Blue; Ivoclar Vivadent, Schaan, Liechtenstein) was applied for 30 seconds, after which the teeth were rinsed with water for 20 seconds and dried with oil-free compressed air until the enamel acquired a white appearance. Specimens in groups 2, 3, and 4 were sandblasted with a microetcher (Danville Engineering, Danville, Calif), with 27-, 50-, and 90-μm aluminum oxide particles at 70 psi for 3 seconds at a distance of 5 mm, perpendicular to the lingual surface of the tooth. Sandblasting was performed by positioning the specimens in a device that ensured standardized distances and application angles. Then, 37% orthophosphoric acid was applied, as described for group 1.

After the lingual surfaces had been prepared, new images of each tooth were captured at the same areas evaluated at T1. Roughness was measured as at T1, and the results provided mean Ra and Rz values for each tooth at T2.

Lingual enamel roughness changes in each group were evaluated according to the increase of roughness in each tooth. For that purpose, the differences between the values of Ra and Rz after conditioning (T2) and before conditioning (T1) were calculated.

The roots of 4 maxillary premolars were sectioned with a carbide disc, and the buccal surfaces were planed with a polisher with waterproof sandpaper, so that it would be easier to position their crowns on the metal holders. After that, the lingual surfaces ($n = 4$) were cleaned with pumice and prepared according to one of the conditioning protocols described above. They were subsequently washed in distilled water, dehydrated in graded concentrations of ethanol, mounted on aluminum stubs with their treated surfaces facing up using a colloidal silver adhesive, and sputter-coated with gold in a Bal-Tec SCD 050 apparatus (Leica Microsystems, Wetzlar, Germany) and examined in a scanning electron microscope (LEO 450 model; LEO Electron Microscopy, Ltd, Cambridge, United Kingdom) operated at