Original Article

Influence of enamel sandblasting prior to etching on shear bond strength of indirectly bonded lingual appliances

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ABSTRACT

Objective: To test the null hypothesis was that there is no difference in the mean shear bond strength of indirectly bonded lingual brackets prepared with or without sandblasting prior to acid etching.

Materials and Methods: Forty extracted human premolars were obtained and randomly divided into two groups of 20 each: group I (control), phosphoric acid and indirect bonding with Maximum Cure and Phase II (Reliance, Itasca, Ill); and group II, sandblasting with 50 μm aluminum oxide (Microetcher, Danville Engineering, Danville, Calif) prior to etching and indirect bonding. All products were used according to the manufacturer's instructions. Instron universal testing machine was used to apply an occlusogingival shear force directly onto the enamel-bracket interface at a speed of 0.5 mm/min. The groups were compared using unpaired Student's *t*-test. Kaplan-Meir survival plots and log-rank test were done to compare the survival distribution between the two groups.

Results: Mean (SD) shear bond strength for group I was 13.17 (4.33) MPa and for the group II was 16.42 (5.41) MPa. Significant difference was observed in the bond strengths of the two groups evaluated ($P = .048$). However, the log-rank test demonstrated that clinical performance of the groups evaluated was not significantly different ($P = .091$). The adhesive remnant index (ARI) was significantly higher when using sandblasting prior to acid etching than in the control group ($P = .011$).

Conclusions: Intraoral sandblasting prior to enamel etching increased the bond strength of lingual brackets, but the clinical performance of the groups was not significantly different. (*Angle Orthod.* 2011;81:149–152.)

KEY WORDS: Air-abrasion; Enamel sandblasting; Indirect bonding; Lingual appliances

INTRODUCTION

The lingual technique is an esthetic alternative to orthodontic appliances bonded to the buccal surfaces of the teeth. Improved laboratory processes are making treatment with lingual appliances cost-effective and are thus enhancing the likelihood of this therapeutic alternative being integrated into routine orthodontic practice. However, the bracket failure rate and the indirect rebonding technique still remain considerable limitations during lingual orthodontic treatment.[1,2]

The success of sandblasting techniques to improve the bond strength when bonding artificial surfaces such as gold, ceramic, and amalgam[3] and when bonding lingual retainers[4] suggests that sandblasting enamel directly before acid etching may be an effective procedure to prepare teeth and to increase bond strength of lingual orthodontic brackets.[5]

The purpose of this study was to evaluate the influence of enamel sandblasting prior to etching on shear bond strength of lingual appliances indirectly bonded. The null hypothesis was that there would be no difference in the mean shear bond strength of

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lingual brackets indirectly bonded with composite to enamel prepared with or without sandblasting prior to acid etching.

MATERIALS AND METHODS

The sample size for each group was estimated based on the number of brackets required because this was the unit of measurement. A sample size of 28 brackets (n = 14) will be sufficient to detect a difference of 5 MPa between groups, with 80% power and a 5% significance level (StatMate 2.0, GraphPad Software, San Diego, Calif). A total of 40 human upper premolars free from caries, cracks, and restorations were used. These teeth had been extracted for orthodontic reasons and with the informed consent of the patients. Ethical approval was obtained for collection of the teeth from the State University of Rio de Janeiro Research Ethics Committee. The teeth were washed in water and stored in a 0.1% thymol solution, for no longer than 6 weeks before use.

Lingual orthodontic maxillary premolar brackets (Gen 7, Ormco, Orange, Calif) were used throughout the study. The average bracket base surface area was determined to be 14.22 mm.[2] The indirect bonding technique was performed in the following manner: the lingual surfaces of teeth were painted with separating medium and then dried. The bracket base was cleaned with acetone for 5 seconds. Chemically cured adhesive paste Phase II (Reliance Orthodontic Products, Itasca, Ill) was applied to the bracket to form the custom composite base, and then pressed firmly on the lingual surfaces of the tooth. Excess adhesive was removed with a small scaler. Transfer trays were made from acrylic resin (Duralay, Reliance Dental Products, Itasca, Ill) for each tooth. After the transfer tray material had set, the specimens were soaked in warm water for 30 minutes. The transfer trays with the brackets were removed from the teeth. The composite adhesive on the custom bracket base was cleaned with acetone for 5 seconds.

After cleaning the teeth with a rubber cup and slurry with pumice and water at a low speed for 5 seconds, they were rinsed with water spray and dried with compressed air for an additional 5 seconds. The teeth were randomly assigned into two groups of 20 specimens, and the brackets were indirectly bonded on the lingual surfaces by the same operator according to the manufacturer's instructions following one of the two protocols:

- Group I (control) — The teeth were etched with 37% phosphoric acid gel (Reliance Orthodontic Products) for 30 seconds, then rinsed thoroughly with water for 30 seconds, and completely dried with compressed oil-free air. Maximum Cure Sealant (Reliance Orthodontic Products) was used to bond the custom bracket bases to the lingual surfaces of the teeth.
- Group II (sandblasting) — The lingual surfaces were sandblasted at 65 to 70 psi for 3 seconds at a distance of 5 mm with 50 μm aluminum oxide powder using a Microetcher (Danville Engineering, Danville, Calif), followed by acid etching for 30 seconds. The brackets were bonded with Maximum Cure Sealant as in group I.

After bonding of the sealant was completed, the transfer trays were removed. The specimens were mounted in plastic rings with acrylic. A mounting jig was used to align the bracket base to be perpendicular with the bottom of the mold and parallel to the force during the shear strength test. An Instron universal testing machine (Instron Ltd, High Wycombe, UK) was used to apply an occlusogingival load to the bracket, which produced a shear force at the tooth-bracket interface with a crosshead speed of 1 mm/min. The force in Newtons was recorded for each specimen and divided by the surface area of the bracket pad to obtain the shear stress value in megapascals (MPa).

After debonding, the teeth and brackets were examined under a 10× magnification with a stereoscopic magnifying glass (Carl Zeiss, Goettingen, Germany) by a blinded operator to evaluate the amount of resin remaining on the tooth. The adhesive remnant index (ARI)[6] was used to describe the quantity of resin remaining on the tooth surfaces. The ARI score has a range between 0 and 3 as follows: 0, no adhesive remained on the tooth; 1, less than half of the enamel bonding site was covered with adhesive; 2, more than half of the enamel bonding site was covered with adhesive; and 3, the enamel bonding site was covered entirely with adhesive.

Descriptive statistics, including the mean, standard deviation, and minimum and maximum values were calculated for each group tested. The data of bond strength were tested for normality with the Shapiro-Wilk method. The unpaired Student's *t*-test was used to determine whether significant differences were present in the bond strength between the two groups. The Kaplan-Meier survival analysis for shear bond strength was done. A log-rank test was used to calculate the overall *P* value for the test of equality of survival distributions between the two groups. The chi-square test was used to evaluate differences in the ARI scores between groups. All statistical analyses were performed with the software Prism 4.0 (GraphPad Software) at the 5% level of significance.

RESULTS

The descriptive statistics comparing the shear bond strength of the two groups are given in Table 1. The

Table 1. Results of Student's *t*-test Comparing Shear Bond Strengths of Groups

Groups Tested	n	Mean* N	Mean* MPa	SD, MPa	Range, MPa
I, Control	20	187.28	13.17	4.327	5.09–22.51
II, Sandblasting	20	233.49	16.42	5.414	9.88–30.6

* $t = 2.040$; $P = .0487$.

unpaired Student's *t*-test showed a poor but significant difference ($P = .048$) between groups evaluated. The control, group I, had mean shear bond strength of 13.17 (±4.33) MPa, whereas the sandblasting group II had a mean of 16.42 (±5.41) MPa (Figure 1).

The Kaplan-Meier survival plots showed that the performances of the groups were not different from each other (Figure 2). A significant difference ($P = .091$) between the two groups was not observed with the log-rank test.

The ARI scores for the two groups tested are listed in Table 2. The results of chi-square comparisons for the ARI indicated that there was a significant difference ($P = .011$) between group II that was bonded with sandblasting prior to acid etching as compared with control group I. In the sandblasting group II, there was a higher frequency of ARI scores of 2, which indicated that more composite remained on the teeth, if compared with control group I.

DISCUSSION

The null hypothesis was rejected. The results of this study showed that the adhesive strength between enamel and lingual brackets can be significantly increased by intraoral sandblasting prior to etching. On the other hand, the Kaplan-Meier survival distribution curves demonstrated that clinical performance of the groups evaluated was not significantly different.

Only upper premolars were used in this investigation. As the different mandibular tooth anatomy requires a different amount of composite used in the indirect pad construction, probably the bond strength of lingual appliances could be affected.

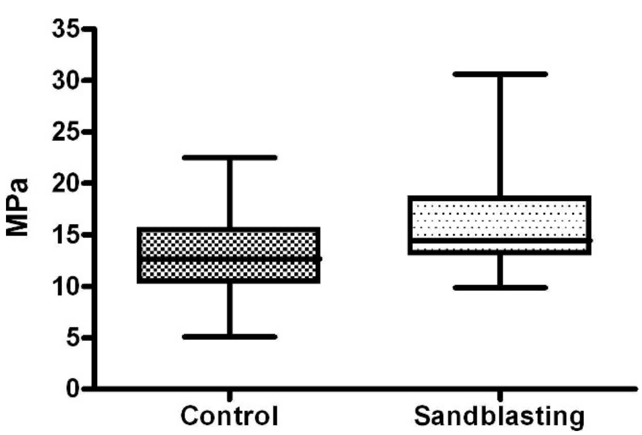

Figure 1. Box plots for the experimental groups.

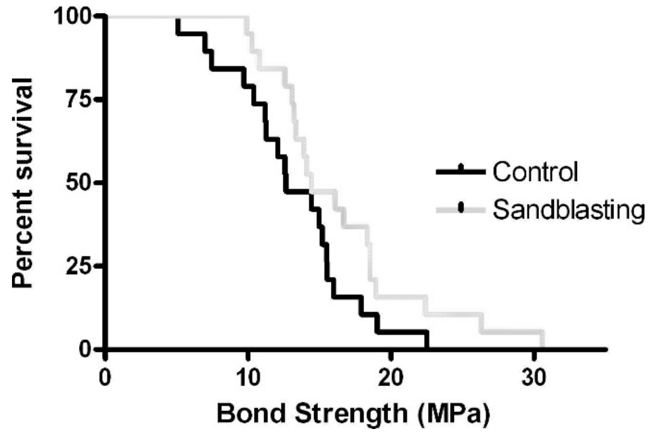

Figure 2. Kaplan-Meier survival plots.

The evaluation of the ARI scores indicated significant difference in bond-failure site between the two groups. These results showed that the sandblasting group II left more adhesive on the enamel than the control group I. This fact can be disadvantageous for clinicians when removing the adhesive after debonding brackets,[7] although bond failure at the bracket-adhesive interface or within the adhesive is more desirable than at the adhesive-enamel interface because enamel fracture has been reported at the time of debonding.[8,9]

A weakness of the original study design was that the required sample size (n = 14) was calculated to show a difference of 5 MPa at a 5% significance level with a power of 80%. In the present study the analysis of the bond strength between the groups is significant with $P = .0487$, which rounds up to 0.05. Maybe a sample size calculation to show a difference at $P < .01$ have been required more teeth in both groups, although not usual in bonding studies. This was compensated for, however, by the increase in the actual sample size used (n = 20), and also by the survival analysis showing accurate data about the clinical performance

Table 2. Frequency Distribution and Results of Chi-square Analysis of the ARI of Experimental Groups

Groups Tested	n	ARI Scores[a*] 0	1	2	3
I, Control	20	12	7	1	0
II, Sandblasting	20	12	1	7	0
Total	40	24	8	8	0

[a] ARI indicates adhesive remnant index; 0, no adhesive remaining on tooth; 1, less than half of the enamel bonding site covered with adhesive; 2, more than half of the enamel bonding site covered with adhesive; and 3, enamel bonding site covered entirely with adhesive.
* $\chi^2 = 9.000$; $P < .0111$.

of the groups. Laboratory studies have the advantage of being able to control and limit the many variables that affect shear bond strength in the mouth. The present study was carried out using human premolars and lingual appliances to simulate the clinical situation. Other studies evaluating the effects of enamel sandblasting prior to acid etching used bovine teeth and composite blocks[10] or conventional appliances on buccal surfaces of premolars.[5]

Results of the present study are in agreement with those of Wiechmann,[10] but not with those of Reisner et al.[5] who observed no significant difference between the two protocols. However, direct comparison between investigations testing identical materials should be interpreted with caution because there is no standardized protocol for shear bond strength studies.

Despite the fact that the acid-etching technique has become more conservative and less invasive,[11] with weaker adherence levels being tolerated, this development should not be transferred to lingual orthodontics, since high adhesive strength between bracket and tooth is an essential factor in the treatment concept.[10]

The enamel sandblasting prior to etching appears to be a useful procedure in lingual orthodontics, although the survival plots have demonstrated that the clinical performance is similar. High adhesive strength between bracket and tooth is an important requirement for the successful integration of lingual orthodontics into everyday practice. However, surface roughening of enamel is a highly complex phenomenon. Many factors of enamel sandblasting have to be considered, including the particle size, shape, and hardness of the abrasive, and the use with or without water.[12] In order to recommend large-scale use of this procedure, more studies are required, particularly in vivo studies and clinical trials.

CONCLUSONS

- Intraoral sandblasting prior to enamel etching of upper premolars increases the shear bond strength of lingual brackets indirectly bonded in vitro, although the clinical performance of the groups evaluated was not significantly different.
- The amount of adhesive on enamel after debonding was significantly higher for the sandblasting group than for the control group I.

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