Original Article

Effects of Different Chlorhexidine Formulations on Shear Bond Strengths of Orthodontic Brackets

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ABSTRACT

Objective: To test the hypothesis that the application of different chlorhexidine formulations to the etched enamel will not affect shear bond strength (SBS).

Materials and Methods: Forty-four freshly extracted human premolars were collected and stored in distilled water. The teeth were etched with 37% phosphoric and were rinsed and dried. The teeth then were divided into four equal groups. While Group 1 served as a control, Groups 2 to 4 were treated before bonding with a chlorhexidine formulation that included solution (2%), gel (1%), and mouthwash (0.2%). Orthodontic brackets were bonded with Transbond XT (3M Unitek, Monrovia, Calif). Bond strength results were evaluated with the use of one-way analysis of variance (ANOVA) ($P < .05$) and post hoc tests. Modes of failures were verified by means of scanning electron microscopy.

Results: Although no statistically significant difference was observed between Groups 1 and 4 ($P > .05$), both were statistically superior to Groups 2 and 3 ($P < .05$). In this in vitro study, the observed measures for Groups 2 and 3 (14.5–10.6 MPa) were lower than those for Groups 1 and 4 (27.3–24.9 MPa), but these values were much higher than those required for clinical use (6–8 MPa).

Conclusion: The hypothesis is rejected. The application of chlorhexidine mouth rinse before bonding had no significant effect on the SBS value, and the application of chlorhexidine solution and gel significantly decreased SBS. (*Angle Orthod.* 2008;79:312–316.)

KEY WORDS: Shear bond strength; Orthodontic bracket; Chlorhexidine gel; ARI score

INTRODUCTION

Fixed orthodontic appliances can be thought of as a caries risk for patients. These patients exhibit changes in oral ecology microflora such as a lower pH environment, increased retentive sites for microbial plaque, and retention of food particles, which may lead to increased proportions of salivary mutans streptococci (MS).[1–3] Despite recent advances in orthodontic materials and techniques, enamel decalcification and white spot lesion formation continue to pose problems for patients treated with fixed orthodontic appliances.[4,5] Decalcification is detected more commonly on the buccal surfaces of orthodontically treated teeth than on the other surfaces of the same teeth.[6]

In these cases, to eliminate and/or minimize the caries risk, preventive efforts should concentrate on the direct suppression of cariogenic microflora by chemotherapeutic agents. Chlorhexidine (CHX) is the most potent documented antimicrobial agent against MS and dental caries. It is commercially available in the forms of mouth rinse, gel, and varnish.[7–9]

Studies of high and low concentrations of CHX have been reported to reduce the number of MS in plaque and saliva, and investigators have concluded that the use of 0.12% CHX mouth rinses could be beneficial for orthodontic patients in achieving improved oral hygiene.[10] Evidence of the efficacy of CHX in biofilms was reported by Pratten et al.[11] The literature suggests that the use of 1% CHX gel significantly decreases MS levels.[12,13]

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The effects of various CHX formulation applications on the shear bond strength (SBS) of orthodontic brackets was assessed in vitro previously.[1,14–16] From these study findings, it can be noted clearly that enamel surface treatment with CHX can increase,[14] decrease,[15] or not interfere with[16] bond strength between brackets. To our knowledge, however, no studies to this time have explored the effects and bond strengths when different CHX formulation gels are applied to etched enamel. Consequently, the present study sought to investigate whether disinfection with CHX solution, gel, and mouth rinse affects the bond strength of metal brackets used in orthodontic treatment.

MATERIALS AND METHODS

Forty-four freshly extracted human maxillary premolars extracted with orthodontic indications were used in this study. The teeth were stored in 0.1% thymol solutions at room temperature immediately after extraction and were used within 4 weeks. Teeth that had hypoplastic enamel, fractures, or caries were excluded. Each tooth was embedded individually in autopolymerizing acrylic resin (Meliodent, Herause Kulzer, Hanau, Germany). The teeth were cleaned and polished with nonfluoridated flour of pumice (Moyco Industries, Montgomeryville, Pa) in a rubber prophylactic cup for 10 seconds and then were rinsed with a stream of water for 10 seconds. The teeth were kept in distilled water, except during bonding and testing procedures. The 44 premolars were randomly divided into four groups, with 11 premolars included in each group.

Group 1 (Control)

The enamel surface was etched with 35% phosphoric acid (3M Dental Products, Monrovia, Calif) for 30 seconds, washed for 20 seconds, and dried for the same duration of time. Transbond XT primer (3M Unitek, Monrovia, Calif) was applied to the etched surfaces, and the brackets were bonded with the use of only Transbond XT composite (3M Unitek). Excess resin was removed with a scaler; the bracket was pressed lightly to verify its seating on the tooth and then was light-cured. All specimens were light-cured with a 1000 mW/cm^2 light-emitting diode (LED) device (Elipar Freelight, 3M ESPE, Germany) for 20 seconds from the mesial, distal, occlusal, and gingival directions of the bracket to ensure complete curing.

Group 2

The enamel surface was etched and dried in the same way as for Group 1. Before the bonding procedure was performed, 2% CHX solution (Drogsan Pharmaceuticals, Ankara, Turkey) was painted onto the etched enamel with a brush for 20 seconds and was left to dry for 30 seconds. The bonding procedure was carried out as in Group 1.

Group 3

The enamel surface was etched and dried in the same way as for Group 1. Before the bonding procedure was performed, 1% CHX gel (Drogsan Pharmaceuticals) was painted onto the etched enamel with a brush for 20 seconds and was left to dry for 30 seconds. The indirect bonding procedure was carried out as for Group 1.

Group 4 (Chlorhexidine Mouthwash)

The enamel surface was etched and dried in the same way as for Group 1. Before the bonding procedure was performed, a mouthwash that contained 0.2% CHX gluconate (Drogsan Pharmaceuticals) was applied onto the etched enamel with a brush for 20 seconds and was left to dry for 30 seconds. The bonding procedure was carried out as in Group 1.

Orthodontic metal brackets (Generus-Roth, GAC International, Bohemia, NY) with a base area of approximately 12.35 mm^2 were used to bond all teeth. After bonding, all samples were stored in distilled water at 37°C for 24 hours and were tested in shear mode on a universal testing machine (Instron, Testometric Co Ltd, Rochdale, UK). Samples were mounted in the jig attached to the universal testing device. For shear testing, specimens were secured in the lower jaw of the machine, so the bracket base of the sample paralleled the direction of the shear force. The specimens were stressed in an occlusogingival direction at a crosshead speed of 0.5 mm/min. The force required to dislodge the bracket was recorded in Newtons, and this value was converted to megapascals.

Determination of Fracture Sites

Brackets and enamel surfaces were examined under a stereomicroscope at 10× magnification for detection of any remaining adhesive, in accordance with the modified adhesive remnant index (ARI). Possible values for the ARI include the following: 0, no adhesive left on the tooth, failure between adhesive and enamel; 1, less than half of the adhesive left on the tooth; 2, more than half of the adhesive left on the tooth; and 3, entire adhesive amount left on the tooth with an impression of the bracket mesh.[17]

Statistical Analysis

Descriptive statistics, including mean, standard deviation, and minimum and maximum stress values,

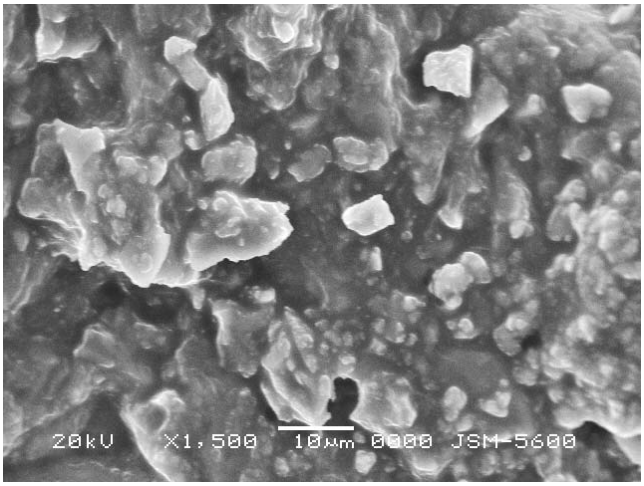

Figure 1. Representative SEM (scanning electron microscope) photographs of enamel surfaces of Group 1 at 1500× magnification.

were calculated for each of the experimental groups. One-way analysis of variance (ANOVA) was used to determine whether significant differences existed between the ''means'' of the various experimental groups. To determine whether these means were significantly different from each other, a Tukey test was employed at the chosen level of probability ($P < .05$). A chi-square test was used to identify significant differences between ARI scores in experimental groups.

SEM Observations

After fracture, one specimen from each group was sputter-coated with gold, prepared for scanning electron microscopy (SEM), and observed under the SEM (JSM-5600, JEOL Ltd, Tokyo, Japan) at 1500× magnification (Figures 1 to 4). Representative images for the various surface treatments were captured digitally and stored in computer files.

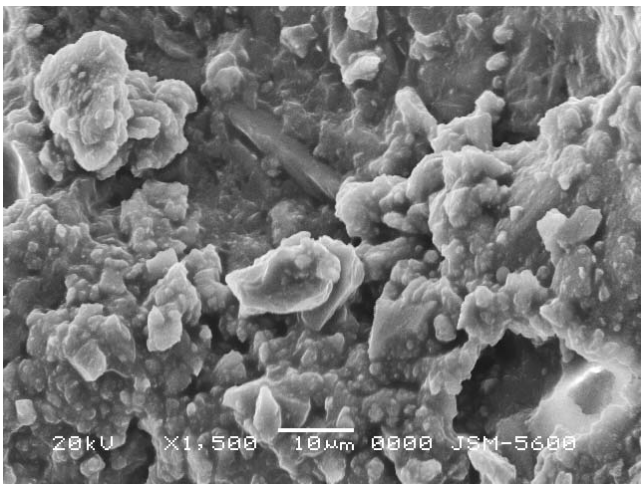

Figure 2. Representative SEM (scanning electron microscope) photographs of enamel surfaces of Group 2 at 1500× magnification.

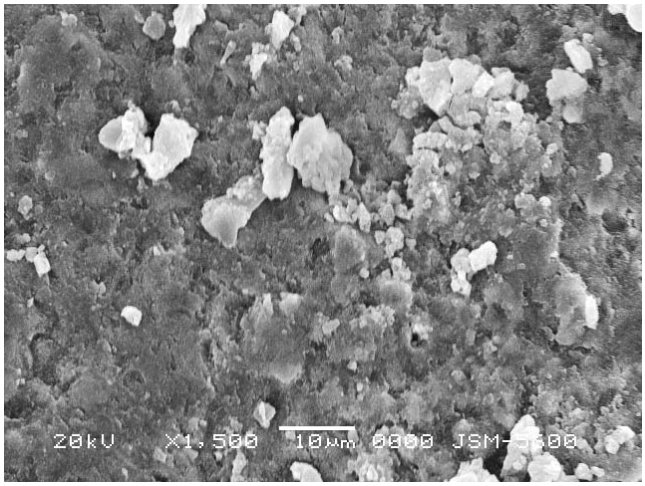

Figure 3. Representative SEM (scanning electron microscope) photographs of enamel surfaces of Group 3 at 1500× magnification.

RESULTS

Shear Bond Strength

Shear bond strengths in MPa (mean standard deviation [SD]) for all groups are shown in Table 1. One-way ANOVA showed significant differences in bond strength between groups ($P < .05$). When CHX gel and solution were applied after the enamel surface was etched, the SBS of the orthodontic bracket resin was lower than that of the control ($P < .05$). However, application of a CHX mouth rinse onto the etched surface did not affect the SBS of orthodontic bracket resin when compared with control values ($P > .05$).

Adhesive Remnant Index (ARI)

Data on residual adhesive on the enamel surfaces as evaluated by ARI scores are presented in Table 2.

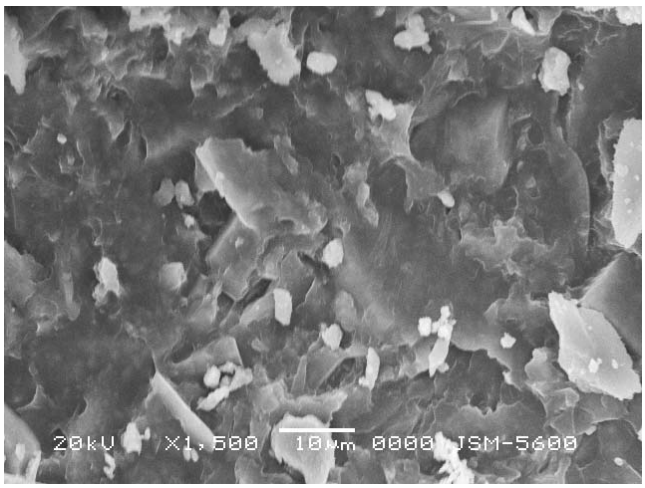

Figure 4. Representative SEM (scanning electron microscope) photographs of enamel surfaces of Group 4 at 1500× magnification.

Table 1. Results (MPa) and Statistical Analysis of the Evaluated Groups[a,b]

Groups	n	Mean	SD
Control	11	27.3[a]	2.68
CHX solution[c]	11	14.5[b]	1.69
CHX gel	11	10.6[b]	1.60
CHX mouthwash	11	24.9[a]	2.75

[a,b] Values with the same letter are not significantly different at $P < .05$.

[c] CHX, chlorhexidine.

Table 2. Frequency of Low and High Adhesive Remnant Index (ARI) Scores in Experimental Groups[a–c]

	ARI Scores					
Experimental Groups	0	1	2	3	N	Grouping[a,b]
Control groups	1	4	5	1	11	a
2% CHX irrigation	10	1	–	–	11	b
2% CHX gel	8	2	–	1	11	b
0.2% CHX mouthwash	6	4	–	1	11	b

[a,b] No statistical difference was noted between the same letters in the same column ($P > .05$).

[c] ARI values were analyzed by means of the chi-square test. ARI scores: 0 indicates no adhesive left on tooth surface, failure between adhesive and enamel; 1, less than half of adhesive left on tooth surface; 2, half or more of adhesive left on tooth; and 3, all adhesive left on tooth surface, failure between adhesive and bracket base.

Chi-square analysis of ARI scores revealed a statistically significant difference between groups ($P < .05$). Group 1 showed a higher frequency of ARI scores of 1 and 2, which indicated cohesive failure in the resin, but in the other groups, ARI scores were 0 and 1. Especially in the two groups in which CHX gel and solution were applied directly over the etched enamel, little or no adhesive was remaining on the tooth (ARI scores 0 and 1), that is, all the adhesive stayed on the bracket base. These failures were most often adhesive at the resin/enamel interface.

DISCUSSION

Placement of a fixed orthodontic appliance hinders tooth cleaning and favors the retention of dental plaque, yielding an increased number of cariogenic bacteria. MS are closely associated with decalcification, and several studies have reported an increase in the number of MS that are present following the placement of orthodontic appliances. Despite all of the advances that have been made in orthodontic materials and applications, decalcification caused by MS is a common complication during and after the orthodontic treatment period if good oral hygiene is not maintained.[18,19]

In this study, the control and CHX mouth rinse groups had higher SBS values than were seen with the other applications (Groups 2 and 3), and differences between the two groups were not statistically significant. This result indicates that application of 0.2% CHX mouth rinse onto the enamel surface after etching does not adversely affect the bond strength of the adhesive. Demir et al[14] and Filler et al[20] reported similar findings after a CHX-immersing procedure with 0.12% CHX gluconate. Even though some investigators have agreed with these findings, they also reported a decrease in bond strength when CHX varnish was applied as a layer onto the etched enamel surface, indicating that SBS values and bracket failure rates were too low to be clinically acceptable.[21] Our results are in accord with those reported by both studies discussed above.

Results of this study indicate that Group 2 (2% CHX solution) and Group 3 (1% CHX gel) had the lowest SBS values. Application of CHX gel and solution immediately before the bonding procedure was performed significantly lowered bond strength values. The probable explanation is that CHX is well tolerated and is absorbed easily by the enamel surface, thus increasing the negativity of the enamel surface and jeopardizing the bonding procedure.[21]

Bond strength values in Groups 1 and 4 were acceptable when compared with those described in the study by Reynolds.[22] However, most of the measurements obtained in Groups 2 and 3 were lower than those derived from Groups 1 and 4 and were greater than the minimum values recommended by Reynolds. The mean bond strengths for the variable groups in this study ranged from 10.6 to 27.3 MPa. An important factor is whether the mean bond strengths are within what is considered a clinically acceptable range. The literature, however, is not clear on what the minimum bond strength should be. Some authors reported that the needed SBS ranges from 13.0 to 21.0 MPa,[23] whereas others reported a range from 6.0 to 8.0 MPa.[22,24] The mean SBS of all composites tested in this study was greater than the 6.0 to 8.0 MPa range reported by Reynolds and Von Frauhofer[25] and others to be adequate for routine clinical use. The mean SBS values were well within the clinically acceptable range of bond strengths.

Significant differences in ARI scores were noted between Group 1 and the other groups. Group 1 had a significantly higher frequency of scores 1 and 2, with most adhesive remaining on the tooth after debonding, indicating failure at the bracket/adhesive interface. The ARI scores of Groups 2, 3, and 4 included a significantly higher percentage of scores 0 and 1, which indicated that little or no adhesive remained on the tooth. Most scores ranged between 0 and 1, indicating that most of the composite remained on the bracket surfaces after debonding. These results suggest that

the bond between bracket and adhesive is stronger than that between enamel and adhesive in Groups 2, 3, and 4. ARI scores reported in this study are in agreement with those reported by previous studies.[1,21,25,26]

Differences in SBS between the various groups are reflected in the distribution of ARI scores (Table 2). When CHX gel solution or mouth rinse was applied to the etched enamel surface as a separate layer, the failure rate increased, and the site of bond failure significantly shifted toward the composite/enamel interface (ARI scores of 0 and 1). This indicates that the adhesive could be effective in bonding to the enamel.

It is important to remember that in vitro conditions may not correspond well with clinical success in the oral cavity, where complex environmental variations in temperature, stresses, humidity, and acidity are evident.

CONCLUSIONS

- The application of CHX mouth rinses that contain an etched enamel surface did not adversely affect the SBS of the adhesive; the application of CHX solution and gel decreased bond strength.

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