Effect of applying chlorhexidine antibacterial agent on the shear bond strength of orthodontic brackets

Samir E. Bishara, BDS, DDS, D Ortho, MS; Paul L. Damon, DDS; Marc E. Olsen, DDS; Jane R. Jakobsen, BA, MS

The practice of orthodontics is constantly improving with the use of new techniques and materials that benefit both the patient and the clinician. The use of fixed appliances provides a significant challenge to the patient who wants to maintain good oral hygiene and avoid or minimize decalcification of enamel during treatment.[1,2] A number of investigators have reported significant increases in salivary and plaque levels of streptococcus mutans in patients undergoing fixed appliance treatment.[2,3] This increase occurs as early as the first week after placement of the appliance.[3] Øgaard and Rølla[4] suggested that during a severe cariogenic challenge even fluorides may have a limited effect in the prevention of decalcification. They suggested that fluoride agents could be further improved by the addition of antibacterial agents such as triclosan, xylitol, or chlorhexidine.[4]

The effect of chlorhexidine varnish treatment on salivary mutans streptococcal levels has been evaluated by Sandham et al.[5] They indicated that chlorhexidine varnish therapy was acceptable to children. They also found that the varnish was effective in suppressing oral mutans levels for at least 3 months and even up to 7 months after application when used prior to the placement of fixed orthodontic appliances.[5]

Abstract

The purpose of this study was to determine whether the application of chlorhexidine as an antibacterial agent affects the shear bond strength and debonding failure modes of orthodontic brackets. Thirty-six recently extracted human premolars were cleaned and randomly assigned to one of three groups: prophylaxis with pumice only, prophylaxis using a 13,500 ppm fluoridated pumice, and prophylaxis with pumice followed by application of 0.12% chlorhexidine paste. All teeth were etched with a 37% phosphoric acid gel and metal orthodontic brackets were bonded to each tooth using the same bonding system. The teeth were mounted in phenolic rings and stored in deionized water at 37°C for 72 hours. A Zwick Universal Testing Machine was used to determine shear bond strengths. The residual adhesive on the enamel surfaces was estimated using the Adhesive Remnant Index. The analysis of variance was used to compare the various groups. Significance was predetermined at $P<0.05$. The results indicated that there were no significant differences in bond strengths between the chlorhexidine-, fluoride-, and nonfluoride-treated teeth ($P=0.233$). The Chi-Square test evaluating the residual adhesive on the enamel surfaces also showed no significant differences ($P=0.456$) between the various groups. In conclusion, the use of chlorhexidine and/or fluoride prophylactic pastes does not significantly affect shear bond strength nor bond failure location of orthodontic brackets.

Key Words

Chlorhexidine • Bond strength • Orthodontic brackets

Submitted: August 1994 **Revised and accepted:** April 1995 Angle Orthod 1996;66(4):313-316.

Table 1
Descriptive statistics and results of comparisons of the shear bond strengths in MegaPascals (MPa) for the three different groups tested

Groups tested	N	$\bar{x}$	SD	Range	
Pumice only	12	11.8	4.1	6.4-19.1	F-Value = 1.48
Fluoride (13,500 ppm)	12	9.5	3.2	5.7-14.9	P=0.233
Chlorhexidine	12	9.6	2.3	5.2-14.9	

N = sample size; $\bar{x}$ = mean; SD = standard deviation; P = probability

Table 2
Scores for the Adhesive Remnant Index (ARI) for the three different groups tested using Chi-Square Analysis (X^2)

Group	1	2	3	4	5 *	
Pumice only	0	5	6	1	0	X^2= 8.795
Fluoride (13,500 ppm)	0	9	3	0	0	P = 0.456
Chlorhexidine	1	8	3	0	0	

* 1, All composite remains on the tooth; 2, more than 90% of the composite remains; 3, more than 10% but less than 90% of the composite remains; 4, less than 10% of the composite remains; 5, no composite remains on the tooth. P = Probability

Chlorhexidine is also an effective adjunct treatment for periodontal disease both as a mouth rinse and as one of the ingredients in toothpaste.[6-9] A number of adults with significant periodontal problems might also be candidates for orthodontic treatment, so it would be of interest to determine whether the use of chlorhexidine will affect the bond strength of orthodontic adhesives. The purpose of the present study was to determine whether the application of chlorhexidine to enamel will affect shear bond strength of orthodontic brackets.

Materials and methods

Teeth

Thirty-six recently extracted human premolars were collected and randomly divided into three groups of 12. The sample size was calculated to be appropriate for the purpose of this study. The teeth were stored in a solution of 0.1% (weight/volume) thymol. The criteria for tooth selection included: having intact buccal enamel, not subjected to any pretreatment chemical agents such as hydrogen peroxide, no caries or cracks due to the extraction forceps.

Materials

The teeth were cleansed, then given one of the following treatments: pumice polish only; prophylaxis with 13,500 ppm fluoridated pumice (Nupro, Johnson and Johnson Dental Products Co, East Windsor, NJ); or prophylaxis with pumice followed by the application of 0.12% chlorhexidine and 1500 ppm monofluorphosphate in a paste (Parogencyl, Laboratoires Pharmaceutiques Goupil; Paris, France). The pastes were left on the enamel surface for 60 seconds after being used to polish the teeth.

Enamel etchant

Each tooth was etched with a 37% phosphoric acid gel applied to the buccal surface for 30 seconds. The teeth were then rinsed with a water spray for 30 seconds and dried with an oil-free air source for 20 seconds.

Adhesive and brackets

Systems 1+ bonding adhesive (Ormco Corporation, Glendora, Calif), was used to bond a metal orthodontic bracket to each tooth (3M Unitek, Monrovia, Calif). The bracket base surface area was determined to be an average of 12.21 mm^2. A force of 300 grams was applied to each bracket and the excess bonding resin was removed with a small scaler.

Debonding instrument

A mounting jig was used to align the buccal surfaces of the teeth perpendicular to the bottom of the acrylic mold. Each tooth was placed in a phenolic ring (Buchler, Ltd, Lake Bluff, Ill) up to the cementoenamel junction and then stored in deionized water at 37°C for 72 hours. The buccal surface of each tooth was aligned to the testing device so that the force applied was parallel to the tooth surface.

A Zwick Universal Testing Machine (Calitek Corp, Riverview, Mich) was used to measure the shear bond strength. A perpendicular force was applied to the bracket by a flat end steel rod from the Zwick machine that produced a shear force at the bracket-tooth interface (Figure 1). The results of each test were recorded electronically on a computer connected to the Zwick machine.

Other variables evaluated

The residual adhesive on the enamel surface following debonding was evaluated using the Adhesive Remnant Index (ARI).[10] The ratings assigned to each tooth ranged from 1 to 5, with 1 indicating that all the composite remained on the enamel surface; 2, more than 90% of the composite remained; 3, more than 10% but less than 90% of the composite remained; 4, less than10% of the composite remained; and 5, no composite remained on the tooth.

Statistical analysis

The descriptive statistics for the debonding strengths of the three groups were calculated and recorded in MPa (N/cm2). A multivariate analysis of variance was performed for the full model. This type of analysis permits the separation of all the potential information in the data into dis-

tinct and nonoverlapping portions, each reflecting certain aspects of the experiment. This analysis prevents the experimenter from paying too much attention to random or isolated results that happen to be significant. Rather, the strength of the association and the pattern of interpretability of the results form the basis of the overall interpretation of the experiment. The presence of an equal number of observations in each cell allows the design to be orthogonal and minimizes the consequences of nonhomogeneous variance.[11] If significant differences were found, Duncan's Multiple Range Test was used to determine which of the means were significant. The Chi-Square Test was used to evaluate differences in the ARI scores between the groups. The significance for both tests was predetermined at $P \leq 0.05$.

Results

Descriptive statistics, including the mean, standard deviation, and minimum and maximum values for each of the three groups are presented in Table 1. The results of the analysis of variance indicated that no significant differences were present in bond strengths between the chlorhexidine-, fluoride-, and nonfluoride-treated groups (P=0.233).

The residual adhesive on the enamel surfaces as indicated by the ARI scores are presented in Table 2. The Chi-Square Test results indicated that no significant differences (P=0.456) were present between the various groups.

Discussion and conclusions

The effects of using fluoride solutions, gels, and rinses on adhesive bond strength has been documented in the literature.[12-16] Chlorhexidine is one of the most widely used broad spectrum antibacterial or antiseptic agents.[6] It has proven to be very effective in controlling plaque and gingivitis, both short-[7] and long-term,[8] without developing resistant organisms in the oral flora. Some of the side effects of using chlorhexidine that limit its widespread acceptance include brown staining of the teeth, increase in calculus deposition, and difficulty in completely masking its taste when used as a rinse.[8] Recently, however, the use of chlorhexidine varnish on the teeth was found to be acceptable to children.[5]

The chlorhexidine rinses available in the U.S. are 0.12% solutions that deliver 18 mg per application (rinse).[13] It has been recommended that at least 30 minutes elapse between the application of chlorhexidine and toothbrushing. This will minimize the interaction between dentifrices containing the commonly used anionic detergent

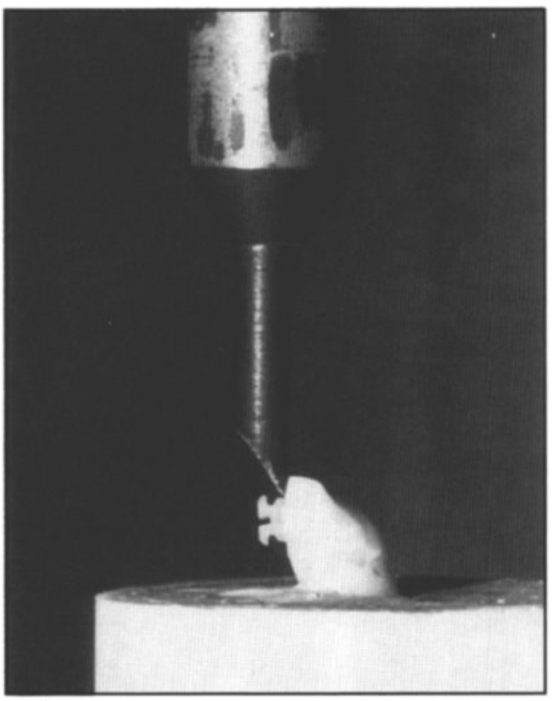

Figure 1

Figure 1
Conventional shear debonding test with the force applied on one side of the bracket in a Zwick Universal Testing Machine.

sodium lauryl sulfate and the cationic chlorhexidine,[6] which could result in its inactivation.[9]

Preparing and cleaning the enamel surface before applying the etchant is an integral part of the procedure for bonding orthodontic brackets to the enamel surface. Gwinnett and Smith[17] reported that prophylaxis before acid etching is recommended to remove plaque and other acquired debris from the tooth, but also suggested that the use of topical fluorides and other agents may reduce bond strength. As a result, prophylaxis with fluoride pastes before acid etching or applying fluoride solutions after etching have not been routinely recommended. Other studies indicated that fluoride application does not significantly affect bond strength.[12-16] Furthermore, the use of topical fluorides has been established as an effective method for reducing decalcification and decay.[18] Similarly, chlorhexidine has been proven to be an effective antibacterial agent.[5,7,8]

The results of this study indicated that shear bond strength was not significantly affected by treating the enamel surface with various concentrations of fluorides and/or chlorhexidine. The group treated with pumice only had the highest bond strength (11.8 MPa), followed by the chlorhexidine group (9.6 MPa) and the 13,500 ppm fluoride group (9.5 MPa). The differences in bond strength between the various groups were not statistically significant, and bond strength values were clinically acceptable. But it

needs to be emphasized that this is an in vitro study and the materials have not been subjected to the rigors of the oral environment.

The ARI scores for the three groups tested showed no significant differences. The majority of the scores ranged between 2 and 3, indicating that most of the composite remained on the enamel surface after debonding. This suggests that, in general, the bond between the resin and the enamel was stronger than that between the bracket and resin.

In conclusion, the findings in this study indicate that treating enamel with either chlorhexidine or fluoridated prophylactic pastes does not significantly affect shear bond strength or bond failure location during the removal of orthodontic brackets. As a result, the use of chlorhexidine and fluoridated prophylaxis products to clean the teeth before acid etching should be recommended as part of the bonding protocol.

Future studies should be conducted to evaluate the effects of applying a chlorhexidine varnish on the enamel surface after etching but before bonding the bracket.

Author Address

Samir E. Bishara
Professor of Orthodontics
College of Dentistry
University of Iowa
220 Dental Science Bldg. S.
Iowa City, IA 52242

Samir E. Bishara, professor of orthodontics, College of Dentistry, University of Iowa, Iowa City, Iowa.

Paul L. Damon is in private practice.

Marc E. Olsen, general practice residency, College of Dentistry, University of Iowa, Iowa City, Iowa.

Jane R. Jakobsen, Assistant Professor, Department of Preventive and Community Dentistry, College of Dentistry, University of Iowa, Iowa City, Iowa.

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