Bond strength following the application of chlorhexidine on etched enamel

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The practice of orthodontics is constantly being improved with the use of new techniques and materials that benefit both the patient and the clinician. Nevertheless, the use of fixed appliances creates a significant challenge for the patient who wants to 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 fluoride may have a limited effect preventing decalcification. They suggested that fluoride action could be further improved by the addition of antibacterial agents, such as triclosan, xylitol, or chlorhexidine.[4]

Chlorhexidine is often used as an effective adjunct in the treatment of periodontal disease, both as a mouth rinse or as one of the ingredients in toothpaste.[5-8] The application of a chlorhexidine varnish before and during orthodontic treatment affects the salivary mutans streptococcal levels.[9]

Sandham et al.[9] indicated that chlorhexidine varnish therapy was acceptable to children, and that the varnish was effective in suppressing oral mutans levels for at least 3 months and up to 7 months after application when used prior to the placement of fixed orthodontic appliances.[9]

Since a number of individuals with significant carious and periodontal challenges might also be

Abstract

The purpose of this study was to determine whether the application of chlorhexidine to etched enamel affects the shear bond strength and bracket/adhesive failure modes of orthodontic brackets. Forty recently extracted third molars were cleaned and divided into two groups of twenty. The first group was etched with a 37% phosphoric acid gel, and a sealant was applied containing a chlorhexidine varnish. Stainless steel orthodontic brackets were bonded using the Transbond XT bonding system (3M/Unitek). Teeth in the second group were etched and bonded using the same bonding system but without chlorhexidine. A Zwick Universal Testing Machine was used to determine shear bond strengths. There were no significant differences in bond strengths between the chlorhexidine treated teeth (= 11.8 ± 2.1 MPa) and the controls (= 12.4 ± 3.1 MPa) ($p = 0.129$). The Chi Square test evaluating the residual adhesive on the enamel surfaces showed no significant differences ($P = 0.136$) between the two groups evaluated. The use of a primer containing chlorhexidine does not significantly affect shear bond strength nor the fracture site (bond failure location).

Key Words

Bonding • Chlorhexidine • Shear bond strength

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Table 1
Descriptive statistics and results of analysis of variance comparing shear bond strengths in megapascals (MPa) for the two different groups tested

Groups tested	N	$\bar{x}$	SD	Range	
Chlorhexidine	20	11.8	2.1	7.05-15.5	F-Value = 2.04
Nonchlorhexidine	20	12.3	3.1	7.33-18.28	P = 0.129

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

candidates for orthodontic treatment, it would be of interest to determine whether the use of chlorhexidine on etched enamel surfaces will affect the bond strength of orthodontic adhesives.

Little or no information is available on the use of chlorhexidine after etching the enamel and before placing the bracket. Therefore, the purpose of the present study was to determine whether the application of chlorhexidine to the etched enamel as an antibacterial agent will affect the shear bond strength and debonding failure modes of orthodontic brackets.

Materials and methods

Teeth

Forty recently extracted human third molars were collected and randomly divided into two groups of 20. The teeth were stored in a 0.1% (weight/volume) thymol solution. The criteria for tooth selection included: intact buccal enamel, not subjected to any pretreatment chemical agents such as hydrogen peroxide, and no caries or cracks due to the extraction forceps. A 10x magnifying glass was used in making these determinations.

Adhesive and brackets

The teeth were cleansed and then pumiced with a rubber prophy cup for 30 seconds. All teeth were etched with a 37% phosphoric acid gel applied to the buccal surface for 30 seconds, then thoroughly rinsed with a water spray for 30 seconds and dried with an oil-free air source for 20 seconds. In the first group, Transbond XT bonding system (3M Unitek, Monrovia, Calif) was used to bond stainless steel brackets (3M Unitek, Monrovia, Calif) to each tooth, following the manufacturer's instructions. In the second group, the same bonding system was used but with a chlorhexidine varnish (Cervitac, Vivadent Schann/Lichtenstein) incorporated in the primer. Two drops of chlorhexidine were added to every one drop of primer and then mixed. The mixture was applied to the etched enamel surface and then light-cured for 30 seconds. The bracket base surface area for the molar bracket was determined to average 18.48 mm^2. A force of 300 grams was applied to each bracket using a Correx gauge (Haag-Streit, Bern, Switzerland) and the excess bonding resin was removed using a small scaler.

The teeth were placed in phenolic rings (Buchler, Ltd, Lake Bluff, Ill) up to the cementoenamel junction and then stored in deionized water at 37°C for 72 hours.

Debonding instrument: A mounting jig was used to align the buccal surfaces of the teeth perpendicular to the bottom of the phenolic ring. 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 (Zwick GmbH & Co, Ulm, Germany) was used to measure the shear bond strengths. 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. The results of each test were electronically recorded in megapascals on a computer connected to the Zwick machine.

Other variables

The residual adhesive on the enamel surface following debonding was evaluated using the Adhesive Remnant Index (ARI).[10] The rating 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 on the tooth; 3, more than 10% but less than 90% of the composite remained on the tooth; 4, less than 10% of the composite remained on the tooth; 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/cm^2).

The analysis of variance was used to compare the two groups, and 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

The descriptive statistics, including the mean, standard deviation, and minimum and maximum values for each of the two 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 ($\bar{x}$ = 11.8 ± 2.1 MPa) and nonchlorhexidine ($\bar{x}$ = 12.3 ± 3.1) treated groups (P = 0.129).

The residual adhesive on the enamel surfaces as evaluated by the ARI scores are presented in Table 2. The Chi Square Test results indicated that no significant differences (P = 0.136) were present between the various groups.

Discussion and conclusion

Chlorhexidine is one of the most widely used broad spectrum antibacterial or antiseptic agents in dentistry.[5] It has proven to be very effective in the control of plaque and gingivitis in both short-[6] and long-term studies[7,11] 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.[7]

More recently,[9] the use of chlorhexidine varnish on the teeth was found to be effective in reducing salivary streptococcal mutans levels in children undergoing orthodontic treatment. The available chlorhexidine rinses in the U.S. are 0.12% solutions and deliver 18 mg per application (rinse).[12] It has been recommended that following the application of chlorhexidine at least 30 minutes elapse before tooth brushing. This will minimize the interaction between dentifrices containing the commonly used anionic detergent sodium lauryl sulfate and the cationic chlorhexidine,[5] which could result in its inactivation.[8]

Adding chlorhexidine to the sealant applied to the etched enamel surface could add increased protection around the bracket periphery but could also adversely influence bond strength. The results from this study indicate that shear bond strength was not significantly affected after treating the enamel surface with a primer containing chlorhexidine (Table 1). In addition, these bond strength values compared favorably to Reynolds'[13] minimal bond strength values that are clinically acceptable (5.9-7.8 MPa). 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.

Table 2
Frequency distribution for the Adhesive Remnant Index (ARI) and results of Chi Square Analysis (X^2) comparing the groups tested

Group	ARI scores* 1	2	3	4	5	
Chlorhexidine	0	6	13	1	0	X^2 = 5.54
Nonchlorhexidine	1	7	7	5	0	P =0.136

*1 All composite remained on tooth; 2 >90% of composite on tooth; 3 <10% but >90% of composite on tooth; 4 <10% of composite on tooth; 5 No composite on tooth. P = probability

The ARI scores for the two 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 (Table 2). This suggests that, in general, the bond between the resin and the enamel was stronger than that between the bracket and resin in both groups tested.

In conclusion, the findings in this study indicate that treating the etched enamel surface with a chlorhexidine-containing sealant does not significantly affect shear bond strength or bond failure location during the removal of orthodontic brackets. As a result, the use of a chlorhexidine-primer mixture following acid-etching could be recommended as part of the bonding protocol.

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