Original Article

Effects of a Chlorhexidine Varnish on Shear Bond Strength in Indirect Bonding

Ömür Polat[a]; Tancan Uysal[b]; Ali Ihya Karaman[c]

Abstract: The purpose of this study was to evaluate the effects of an antimicrobial varnish on the shear bond strength (SBS) of metallic orthodontic brackets bonded with an indirect bonding resin. For this purpose, 60 noncarious human premolars were divided into three equal groups. Group 1 was an indirect bonding control group and, after acid etching of the enamel, the brackets were indirectly bonded to the teeth with an indirect bonding resin. In group 2, before bonding, an antimicrobial varnish was painted on the etched enamel and indirect bonding was carried out as in group 1. In group 3, Transbond MIP primer and the antimicrobial varnish were thoroughly mixed in a 1:2 proportion, applied to the enamel surface, light cured for 20 seconds, and the brackets were direct bonded. A universal testing machine was used to determine the maximum load necessary to debond the brackets, the SBS values recorded, and the adhesive remnant index scores determined. Data were analyzed using analysis of variance (ANOVA), Tukey HSD, and chi-square tests. Results of ANOVA revealed statistically significant differences in the SBS among the various groups tested ($P < .05$). Indirect bonding of brackets with Sondhi Rapid Set after the application of the antimicrobial varnish showed significantly lower SBS when compared with both the group 2, indirect bonding control group, and the group 3, direct bonded-antimicrobial varnish group. (*Angle Orthod* 2005;75:1036–1040.)

Key Words: Cervitec; Indirect bonding; Shear bond strength

INTRODUCTION

Brackets can be bonded on teeth by either direct or indirect methods. Silverman and Cohen[1] introduced the first indirect bonding method in 1972. They used methylmethacrylate adhesive to attach plastic brackets to model casts in the laboratory. An unfilled bis-GMA resin was used as an adhesive between the etched enamel and a previously placed adhesive.

Most clinicians who bond brackets indirectly today use the Thomas[2] method. In this technique, the laboratory procedure is done by placing a filled bisGMA resin on the bracket base. After hardening of the filled resin, brackets are carried to the mouth using a flexible transfer tray. Brackets are bonded using a liquid catalyst resin applied to the etched enamel surface and a base resin applied to the bracket base. The tray is removed when polymerization is completed.

Several studies have been made to modify this technique[3–11] and to compare the bond strengths of the direct and indirect methods.[12–15] Although these studies conclude that no differences exist between the two methods, most of them were made with direct bonding adhesives even when indirect techniques were used.

Currently, two adhesives that were specifically developed for indirect bonding are on the market. One of them is Custom IQ (Reliance Orthodontics, Itasca, Ill) and the other is Sondhi Rapid Set (3M Unitek, Monrovia, Calif). Recently, Klocke et al[16] investigated the bond strengths of these materials and found that the indirect Sondhi Rapid Set method showed similar strength compared with the Transbond XT direct bonding control group and that Custom IQ showed lower values compared with the other groups. Polat et al[17] compared these systems both in vitro and in vivo and found that, even though Sondhi Rapid Set showed significantly lower bond strength than both Custom IQ and direct bonding Transbond XT group, the in vivo

[a] Clinical Instructor, Department of Orthodontics, Faculty of Dentistry, Baskent University, Ankara, Turkey.

[b] Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Erciyes University, Kayseri, Turkey.

[c] Professor, Department of Orthodontics, Faculty of Dentistry, Selcuk University, Konya, Turkey.

Corresponding author: Omur Polat, DDS, PhD, Baskent Universitesi Diş Hekimliği Fakültesi, Ortodonti A.D. 11. sk. No: 26 Bahçelievler, Ankara, Turkey
(e-mail: omur@baskent.edu.tr)

Accepted: September 2004. Submitted: July 2004.

results showed no differences in long-term failure rates.

Different materials and methods for bonding brackets either by indirect or direct methods are constantly being developed, but in certain cases, the problem of decalcification after orthodontic treatment still remains. Patients undergoing orthodontic therapy have changes in oral ecology such as a lower pH environment, increased retentive sites for *Streptococcus mutans*, and increased retention of food particles, which may lead to increased proportions and absolute numbers of salivary *S. mutans*.[18–23] These changes may be responsible, in part, for the observations of postorthodontic treatment decalcification.[24,25]

Øgaard et al[26] indicated that a high prevalence of caries may be caused by the high cariogenic challenge prevailing in the plaque around orthodontic appliances. Proper oral hygiene is more difficult to maintain and pH levels below 4.5 have been measured in the plaque around the brackets and bands during orthodontic treatment.[26] At such a low pH, the remineralization phase is hampered and more fluoride will not necessarily give a better cariostatic effect.[26] For that reason, Øgaard and Rølla[27] suggested that fluoride agents could be further improved by the addition of antibacterial agents.

Bishara et al[28] and Damon et al[29] both studied the effects of chlorhexidine varnish on the bond strength of orthodontic adhesives on etched enamel surfaces. Bishara et al[30] also published data on the effects of various methods of chlorhexidine application on shear bond strength (SBS). They indicated that SBS is not significantly affected when chlorhexidine is applied, if the varnish is premixed with the sealant and applied on the etched enamel surfaces and then light cured.

Karaman and Uysal[31] also investigated the effects of an antimicrobial varnish on SBS and the bracket-adhesive failure modes of metallic orthodontic brackets. They found that the bond strengths of the direct bonding Transbond XT with Transbond MIP (moisture insensitive primer) (3M Unitek, Monrovia, Calif) group and Transbond XT with an antimicrobial varnish, Cervitec®, mixed with Transbond MIP were clinically acceptable. They also found that, although the primer they used had a hydrophilic character (Transbond MIP), the antimicrobial agent in mouthwash form premixed with primer was clinically unacceptable.

The purpose of this study is to evaluate the effects of an antimicrobial varnish (Cervitec) on SBS of metallic orthodontic brackets bonded with an indirect bonding resin (Sondhi Rapid Set) and compare it with an indirect bonding control group (Sondhi Rapid Set) and a direct bonded group prepared with a hydrophilic primer-antimicrobial varnish mixture painted on the previously etched enamel.

TABLE 1. Chemical Composition of Cervitec Varnish[a]

Components	%
Ethyl acetate	< 50%
Ethanol	< 41%
Thymol	1%
Chlorhexidine	1%
Polymer	not given

[a] Data derived from Material Safe Data Sheets of Ivoclar Vivadent.

MATERIALS AND METHODS

Sixty noncarious human premolars, extracted for orthodontic indications, were used in this study. After extraction, the teeth were stored in distilled water continuously. The sample was divided into three random groups of 20 each. Each tooth was mounted vertically in self-cure acrylic so that the crown was exposed.

Before the starting procedure, the surface of each tooth was polished for one minute using the combination of a polishing agent and a brush at a low speed (3000 rpm). A 37% phosphoric acid gel (3M Dental Products, St Paul, Minn) was used for acid etching for 30 seconds. The teeth were rinsed with water for 30 seconds and dried with an oil-free source for 20 seconds. In all etched cases, the frosty white appearance of etched enamel was apparent.

After acid etching, the brackets were bonded in the following manner:

- Group 1 (indirect bonding control): the brackets were bonded to stone models using Transbond XT according to the recommendations of Sondhi.[11] Resin A was applied to the etched enamel and resin B was applied on the bracket base. They were then transferred to etched teeth using Sondhi Rapid Set.
- Group 2 (indirect bonding with an antimicrobial varnish, Cervitec®): before the bonding procedure, Cervitec varnish (Cervitec, Vivadent, Schaan, Lichtenstein) was painted on the etched enamel and left to dry. The indirect bonding procedure was carried out as in group 1.
- Group 3 (direct bonding/antimicrobial varnish, Cervitec®): primer (Transbond MIP) and Cervitec® varnish were thoroughly mixed in a 1:2 proportion, applied to the enamel surface. The enamel surface was light cured for 20 seconds, and the brackets were bonded.

The Cervitec® varnish used in this study contains equal amounts of chlorhexidine and thymol. The chemical components are given in Table 1.

The embedded specimens were secured in a jig attached to the base plate of a universal testing machine (Micro 500, Testometric, Maywood Instruments Limited, Basingstoke, UK). A chisel-edge plunger was mounted in the movable crosshead of the testing ma-

TABLE 2. Descriptive Statistics of the Three Groups[a]

Groups Tested	N	Mean (MPa)	SD (MPa)	Range	Tukey Test*
Group 1 (direct bonding + Cervitec)	20	13.55	3.45	7.50–21.54	A
Group 2 (indirect bonding)	20	11.65	6.57	0.11–21.54	A
Group 3 (indirect bonding + Cervitec)	20	6.12	3.45	2.35–17.32	B

[a] N indicates sample size; SD, standard deviation.
* Groups with different letters are significantly different from each other.

TABLE 3. Frequencies of the ARI Scores[a,b]

	ARI Scores						Multiple Comparison		
Groups Tested	1	2	3	4	5	n	A	B	C
Group A	1		1	3	15	20		NS	**
Group B				6	14	20	NS		**
Group C		1	5	11	3	20	**	**	

[a] ARI scores: 1 = all of composite, with impression of bracket base, remained on tooth; 2 = more than 90% of composite remained; 3 = more than 10% but less than 90% of composite remained on tooth; 4 = less than 10% of composite remained on tooth surface; 5 = no composite remained on enamel. Group A, Sondhi; group B, Sondhi + Cervitec; group C, Transbond + Cervitec.
[b] ARI indicates adhesive remanant index; NS, not significant.
** $P < 0.01$.

chine and positioned so that the leading edge was aimed at the enamel-adhesive interface before the leading edge was brought into contact at a crosshead speed of 0.5 mm/min. The maximum load necessary to debond the bracket was recorded. The force required to take off the brackets was measured in Newtons, and the SBS (one MPa = one N/mm^2) was calculated by dividing the force values by the bracket base area (14 mm^2).

After debonding, all teeth and brackets were examined at a 10× magnification with light microscopy. Any adhesive remaining after bracket removal was assessed with the adhesive remnant index (ARI)[32,33] and scored with respect to the amount of resin material adhering to the enamel surface. The ARI scores were used as a more comprehensive means of defining the sites of bond failure between the enamel, the adhesive, and the bracket base.

Descriptive statistics were calculated for each of the three groups of teeth tested. Comparisons of means were made using analysis of variance (ANOVA) and Tukey HSD tests. The chi-square test was used to determine significant differences in the ARI scores among the different groups. All statistical analyses were performed using the SPSS software package (Statistical Package for Social Sciences for Windows, version 10.0.1, SPSS Inc, Chicago, Ill).

RESULTS

Shear bond strength

The descriptive statistics, including the mean, standard deviation, and minimum and maximum values, for each of the three groups are presented in Table 2. Data were analyzed using ANOVA and Tukey HSD tests. Results of ANOVA revealed statistically significant differences in bond strengths among the various groups tested ($P < .05$). The Tukey multiple range analysis indicated that group 1 (indirect control) (mean 11.65 ± 6.57 MPa) and group 3 (direct bonding/Cervitec varnish) (mean 13.55 ± 3.45 MPa) had similar SBS values. However, group 2 (indirect bonding/Cervitec) (mean 6.12 ± 3.45 MPa) had significantly lower SBS values compared with the other two groups.

Adhesive remnant index

The amounts of residual adhesive on the enamel surfaces as evaluated by the ARI scores are given in Table 3. There were statistically significant differences present among the various groups ($P < .0001$). In groups 1 and 2, there was a higher frequency of ARI scores of five, which indicated little or no adhesive remaining on the tooth. These failures were mostly at the resin-enamel interface. However, in group 3, some amount of adhesive was found on the tooth surface, which differed from groups 1 and 2.

DISCUSSION

Despite all the advances in orthodontic material and treatment mechanics, demineralization around orthodontic brackets still remains a major problem for the orthodontic patient. Hahn et al[34] indicated that microbes accumulate on restorative materials. Among these, *S. mutans* is known to cause secondary caries at the margins of composite restorations as well as directly attack the enamel.

Chlorhexidine is an antimicrobial agent with a broad spectrum that has proven to be very effective in the maintenance of plaque control and gingivitis in both short-[35] and long-term[36] studies. Sandham et al[37] had found that there was a reduction in salivary *S. mutans* levels with the use of chlorhexedine varnish on the teeth in children undergoing orthodontic treatment. Even though brown staining of the teeth, increased calculus deposition, and an unpleasant taste are common side effects, these effects are minor when it is used as a local varnish.

Applying a chlorhexidine varnish to the enamel surface could act as a protective layer against microorganisms around the bracket periphery, but in return could decrease the bond strength. Bishara et al[28] and Damon et al[29] reported that bond strength was not affected after the application of a hydrophilic primer (Transbond MIP) with a chlorhexidine varnish on etched enamel. Karaman and Uysal[31] had also obtained the same result with the application of the same hydrophilic primer premixed with Cervitec varnish. However, they had also found a decrease in bond strength with the application of either another antimicrobial varnish that contained chlorhexidine and ethanol or a chlorhexidine mouthwash.

No information is available on the effects of Cervitec varnish on SBS in indirect bonding procedures. Therefore, the purpose of this study was to evaluate the effects of application of Cervitec varnish on SBS and the adhesive failure modes of metallic orthodontic brackets bonded with an indirect bonding resin. A direct bonding group with Cervitec varnish–Transbond MIP mixture was used on the basis of the results of previous studies. The results indicate that, even though an indirect bonding control group and the direct bonding group that used a hydrophilic primer premixed with Cervitec varnish showed similar and clinically acceptable bond strength values (11.65 $\pm$ 6.57 and 13.55 $\pm$ 3.45), Cervitec varnish used on etched enamel before indirect bonding with Sondhi Rapid Set showed significantly lower SBS values (6.12 $\pm$ 3.45) compared with the other two groups.

Bishara et al[30] applied Cervitec under different conditions. They found that the SBS was not significantly affected when the varnish was applied over the bracket and tooth surfaces after the bonding procedure was completed, as a prophylactic paste over the unetched enamel before bonding, and when the varnish was premixed with the sealant and applied on etched enamel. On the other hand, in all the experimental groups in which the chlorhexidine varnish was applied as a layer on the etched enamel surface or over the sealant, SBS values and bracket-failure rates were too low to be clinically acceptable. In this study, the varnish was applied on the etched enamel before the application of resin A of Sondhi Rapid Set. Sondhi Rapid Set resin A is hydrophobic in nature. Therefore, it was believed that a possible reason for the decreased levels of bond strength achieved in group 2 was the incomplete mixing of resin A and varnish. Higher SBS values could be achieved if the varnish was premixed with a different hydrophobic form of resin A of Sondhi Rapid Set.

Reynolds[38] determined the range of clinically acceptable minimal bond strength values in orthodontics as 5.9 to 7.9 MPa. The bond strength values of groups 1 and 3 compare favorably with Reynolds' values, but most of the specimens in group 3 were below this minimum limit. However, Polat et al[17] had found previously that an indirect bonding group that showed an in vitro SBS value of 6.11 $\pm$ 1.64 MPa had a similar clinical failure rate with another indirect bonding resin group that indicated an in vitro SBS value of 10.33 $\pm$ 4.16 Mpa. Because of the probable differences in in vitro and in vivo test conditions, a final conclusion cannot be made without direct comparisons in the clinic.

The results of ARI scores between the first two groups and group 3 reflect the common failure mode differences between indirect bonding and direct bonding systems. In indirect bonding, it seems reasonable that at debonding, the lower filled resin layer would fracture and most of the composite resin would be removed with the bracket.

Different antimicrobial agents such as chlorhexidine, benzydimine, or triclosan can be applied in the form of mouthrinses, varnishes, or oral sprays. These agents have been shown to be useful adjuncts in plaque and inflammation control. Further investigations of the effects of these agents on microbial accumulation and bond strength in both indirect and direct bonding applications are needed.

CONCLUSIONS

The findings of this study are as follows:

- Indirect bonding of brackets with Sondhi Rapid set after the application of Cervitec antimicrobial varnish showed a significant decrease in SBS when compared with a direct bonding/Cervitec and an indirect bonding group. The separate use of the Cervitec varnish and Resin A of Sondhi Rapid Set seemed to have increased the in vitro failure rates of the brackets.
- Application of an antimicrobial agent before indirect bonding resin did not significantly alter the site of failure during debonding. The failure pattern was similar to that of the indirect bonding control group.

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