Original Article

Six-Month Bracket Survival with a Self-Etch Adhesive

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ABSTRACT

Objective: To evaluate, over a 6-month period, the clinical performance of a self-etch adhesive (Transbond Plus Self-Etching) compared with a conventional adhesive that uses the etch and rinse approach (Transbond XT).

Materials and Methods: One operator, using the straight-wire technique, placed 567 metallic brackets in 30 patients (age range 12–18 years) such that homologous teeth from the same arch received different materials. The brackets were bonded following the manufacturer's instruction except for the fact that the self-etch system was brushed for a longer time than recommended (10–15 seconds). The failure modes were visually classified into three modes: adhesive-enamel, adhesive-bracket, and cohesive failure. The survival rate of the brackets was estimated by Kaplan-Meier and log-rank test ($P < .05$).

Results: The failure rates of the self-etch and conventional adhesives were 10.6% and 7.4%, respectively. The failure rate of the conventional system was 0.3 times greater than that of the self-etch system. The self-etch adhesive showed a higher survival rate compared with the conventional system ($P < .05$). Most of the failures were cohesive and at the adhesive-enamel surface. No difference in the fracture debonding mode was observed for the materials.

Conclusions: These findings indicate that the self-etch Transbond Plus Self-Etching can be safely used for orthodontic brackets because it provides higher survival rates than does the conventional Transbond XT.

KEY WORDS: Self-etch adhesives; Survival rates; Bonding systems; Brackets; Orthodontics

INTRODUCTION

The orthodontic treatment depends, among other factors, on the successful bonding of orthodontic brackets to enamel. The conventional bonding of orthodontic brackets to enamel uses the etch and rinse bonding approach and provides good adhesive results. However, this bonding approach is time-consuming[1,2] because a series of steps has to be followed. Recently, a new group of products, termed self-etching primers, has been introduced in orthodontics to simplify the bonding procedure.[3] These systems combine both the conditioner and the primer into a single acidic primer solution, allowing the elimination of the acid conditioning and rinsing steps required for conventional bonding systems. Therefore, the self-etch primers can simultaneously etch and infiltrate the enamel surface.[4]

One of the self-etch systems available on the market for orthodontic bonding is the Transbond Plus Self-Etching Primer. Numerous in vitro studies have shown that this system provides shear bond strengths similar to the values achieved with etch and rinse systems.[2,5–9] Although laboratory studies can provide a venue for a more standardized approach for evaluating the performance of the dental materials, the in vitro testing does not closely simulate the oral environment, which includes the possibility of contamination with saliva, the stresses placed on the teeth during mastication and occlusion, the degradation of the adhesive when exposed to the saliva, the temperature variations introduced by food or drinks, as well as the skill of the clinician.[10]

Thus far, only a few short- and long-term clinical trials

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Accepted: November 2005. Submitted: July 2005.

have attempted to compare the survival rates of brackets bonded with these different bonding strategies.[1,11–13] A slight and nonsignificant difference on the 12-month failure rate was observed between the self-etch (1.6%) and the conventional adhesive (3.1%) by Aljubouri et al.[1] On the other hand, Ireland et al[11] found a 10.99% failure rate with Transbond Plus compared with a 4.95% failure rate with conventional acid etching over a 6-month period. This high failure rate with Transbond Plus, observed by Ireland et al,[11] was not detected in other clinical studies.[12,13] These findings highlight that there is no consensus among the clinical studies regarding the performance of the self-etch systems for bracket bonding.

Another important factor that should be analyzed when using orthodontic brackets is the mode of failure at debonding. There have been reports of undesirable and alarming enamel fracture and loss at the time of debonding of ceramic brackets.[14] This risk is reduced with the use of metal brackets, but a small degree of enamel fracture might still occur because of the micromechanical nature of the bond between a composite resin bonding agent and the acid-etched enamel surface. At the time of bracket removal, enamel loss can also occur and depends largely on the bracket material and method used for debonding.

Bond failure at adhesive interface or within the adhesive is more desirable and safer than failure at the adhesive-enamel interface because enamel fracture and crazing have been reported at the time of bracket debonding.[15] A recent study on the mode of failure of brackets bonded with varied materials has noted that the adhesive remnant index (ARI) scores were statistically significantly different and there was more bracket base–adhesive interfacial failure with the conventional etch group and more mixed-mode failure with the self-etch adhesive,[16] agreeing with another investigation.[17]

For a new material to be considered innovative, its performance, under clinical circumstances, must be equal to or better than the performance of the procedures and materials currently available. Because there has been limited information on the performance of the self-etch systems for bracket bonding, the aim of this longitudinal randomized clinical study is to compare, over a 6-month period, the clinical performance of a self-etch system and a conventional system.

MATERIALS AND METHODS

Ethical approval for the study was obtained from the University of Passo Fundo Research Committee (Passo Fundo, Rio Grande do Sul, Brazil). A total of 90 patients (12 to 18 years of age) were recruited from the waiting list of the Orthodontic Dental Clinic at the University of Oeste de Santa Catarina (Joaçaba, Santa Catarina, Brazil). However, only 30 patients who met the inclusion criteria were selected. The selected patients did not have any restorations on the buccal surfaces of teeth where brackets were to be bonded and did not have any accentuated occlusal dysfunction that could affect bracket positioning. Patients with very poor oral hygiene were not included in this study. There was no restriction about the malocclusion type present.

Before the beginning of the orthodontic treatment, all patients were instructed about oral hygiene and dental care. In case restorative or extraction procedures were needed, they were performed before the the orthodontic treatment began. The details of sample size, mean age, and patient distribution by sex, age, and tooth type are shown in Table 1.

Table 1. Sample characteristics

	Number	%
Number of patients	30	—
Distribution of patients by sex		
Female	15	50
Male	15	50
Distribution of patients by age, y		
12–13	8	26.7
14–15	10	33.3
16–18	12	40
Number of brackets	567	
Distribution of brackets by sex		
Female	283	49.9
Male	284	50.1
Distribution of brackets by age, y		
12–13	150	26.5
14–15	188	33.1
16–18	229	40.4
Distribution of brackets by tooth type		
Upper incisors (UI)	120	21.1
Lower incisors (LI)	119	21
Upper canines (UC)	60	10.6
Lower canines (LC)	60	10.6
Upper premolar (UP)	100	17.6
Lower premolars (LP)	108	19.1
Distribution of brackets by bonding material		
Conventional	284	51.1
Self-etch	283	49.9

A total of 567 brackets were bonded with fixed orthodontic appliances, according to the straight-wire technique. A single operator performed the bonding procedures to eliminate interexaminer variation. The teeth were cleaned with pumice slurry before the application of one of the following two adhesives: (1) Transbond XT Light Cure Orthodontic Adhesive (3M Unitek, Monrovia, Calif) and (2) Transbond Plus Self-

Table 2. Composition and mode of application of the materials

Material	Composition	Mode of application
Transbond XT	1. Primer: trietylenoglicol-dimethetil-acrylate (45–55%), Bis-GMA (45–55%) 2. Adhesive: silane-treated quartz (70–80%), Bis-GMA (10–20%), dichlorodimethylsinane reaction product with silica (<2%)	(1) Acid etching (15 s), (2) rinsing (15 s), (3) air dry (5 s), (4) primer application (15–20 s), (5) placement of the resin paste on the bracket, and (6) light curing with halogen light (450 mW/cm^2) for 60 s.
Transbond plus self-etching	Methacrylate ester derivative (mixture) (75–85%) and water	(1) Mixture of the components, (2) priming application under rubbing motion for 10–15 s[a], (3) slight air stream (at a distance of 10 cm for 5 s), (4) placement of the resin paste on the bracket, and (5) light curing with halogen light (450 mW/cm^2).

[a] The time recommended by the manufacturer is only 3 seconds.

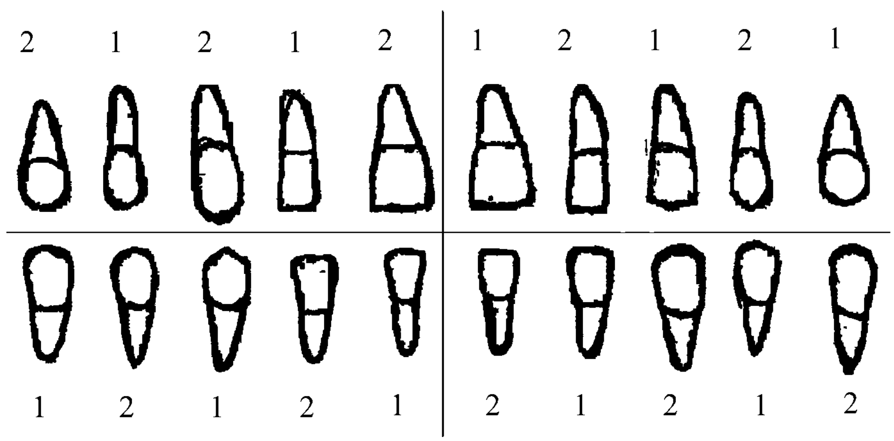

Figure 1. Schematic illustration of the random allocation of the materials in each patient (1, conventional system; 2, self-etch system).

Etching (3M Unitek). The composition and mode of application of these materials are shown in Table 2. From Table 2 it can be seen that the mode of application of the Transbond Plus Self-Etching did not follow the manufacturers' directions. The adhesive was rubbed onto the enamel for 10–15 seconds instead of the recommended 3 seconds. This was because of the fact that previous investigations have reported that prolonged application times can improve the bonding efficacy of self-etch systems to enamel.[18]

The materials were bonded to teeth so that homologous teeth from the same arch received different materials (Figure 1). Usually the split-mouth design was used, but if the patients had occlusal problems on just one side of the mouth, the brackets bonded on that side would be more prone to failure. A coin was tossed to determine the order of the teeth to be bonded in each patient.

After the adhesive application (Table 2), stainless steel brackets Dyna-Lock Twin Roth 0.022 inch (3M Unitek) were coated with an adhesive paste (Transbond XT Light Cure Paste; 3M Unitek). The brackets were positioned in the center of the crown[19] and pressure was applied to seat each bracket fully before removing any excess of resin. The light-curing procedure was performed with a Curing Light XL 1500 (3M ESPE, St Paul, Minn) for 20 seconds on the mesial aspect, 20 seconds on the incisal-occlusal aspect, and 20 seconds more on the distal aspect. The light-curing intensity was checked regularly, and the light output was 450 mW/cm^2.

Every effort was made to minimize variation in the magnitude of orthodontic forces applied to brackets and teeth. The usual choice of aligning archwires was either a 0.0012-inch NiTi wire or a 0.014-inch NiTi wire, depending on the initial level of alignment and crowding. In this study, a 0.014-inch archwire was ligated at least 10 minutes after the bonding procedure (#0.014, 3M Unitek). No bite planes appliances were used during the treatment.

Patients were seen at 40-day intervals, but they were instructed to check for loose or missing brackets every day. A data sheet was used for each patient to record the date of bracket failure and the teeth involved. Bracket failure was visually classified as at the adhesive-enamel interface if there was no material left

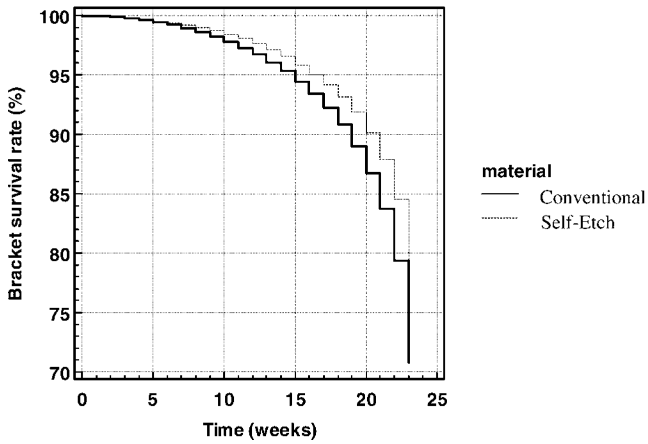

Figure 2. Relationship between the bracket survival rate (%) and the duration of treatment (weeks) for the materials used for bonding.

on the tooth surface. Adhesive-bracket interface failure was characterized by the total absence of adhesive on the bracket base. Cohesive failure was classified according to the presence of some material on the tooth surface and the bracket base.

Brackets were replaced as soon as a bond failure was detected, and the new bonded brackets were not included in the study. All patients were observed for 6 months during their regular orthodontic appointments.

The survival rates of the brackets were estimated by Kaplan-Meier test. The log-rank test, with the level of significance set at 0.05, was used to compare the survival curves. Descriptive statistics were used to describe the frequency distributions of the different failure modes for each adhesive system and were evaluated by a chi-square test ($\alpha = 0.05$).

RESULTS

A total of 30 brackets (10.6%) bonded with the conventional adhesive Transbond XT failed over the 6-month period. For the self-etch Transbond Plus, 21 brackets failed (7.4%). Figure 2 shows the influence of bonding material on survival rate. A significant difference was observed between materials ($P < .0001$). The self-etch adhesive ($S[t] = 0.782$) showed a significantly higher survival rate than the conventional system ($S[t] = 0.708$).

The number of debonded brackets, distributed according to material and failure mode, is shown in Table 3. Most failures occurred at the adhesive-enamel and the adhesive-bracket interface. No significant difference was observed among the materials ($P > .05$).

DISCUSSION

The failure rates observed in this study were high compared with other studies[1,12]; however, the range observed in this study is within those provided by Ireland et al[11] and we have not found any explanation for that. However, as mentioned by Pandis and Eliades,[12] differences in failure rates and contradictory evidence from studies testing identical materials in different populations imply that culturally influenced dietary habits and sex differences can affect the in vivo failure rate of brackets. Thus, the variability observed among studies regarding failure rates or jaw distribution and arch location could be assigned to the foregoing factors.

Table 3. Number of debonded brackets according to materials and fracture patterns

Material	Adhesive-enamel	Adhesive-bracket	Cohesive
Conventional	13	2	15
Self-etch	10	1	10

In the comparison of the two bonding strategies, this investigation demonstrated that the best results were obtained with the self-etch adhesive Transbond Plus. This is partially in accordance with other recent clinical evaluations.[1,12] However, the study of Aljubouri et al[1,] did not detect a significant difference between the conventional and the self-etch adhesive, and the authors claimed that the self-etch system showed a trend toward higher survival rate.[1] Pandis and Eliades[12] have observed low failure rates (0.94%) with the Transbond Plus after 14 months of treatment.

This finding is also in agreement with most laboratory evaluations that showed superior or similar performance of Transbond Plus compared with conventional Transbond XT in dry enamel.[2,5–7] As bracket bonding is not usually performed under rubber dam isolation, a complete dry field is not easily accomplished. This means that any possible contamination can compromise the retention of the appliances, mainly when a moisture-sensitive material is used. Contrary to the hydrophobic features of the conventional Transbond XT, the self-etch adhesive is hydrophilic and therefore can achieve high bond strength values even when the enamel is contaminated with saliva or water.[8,9,20,21] This is because of the hydrophilic monomers and solvents presented in the Transbond Plus composition. The solvents are capable of displacing water from the surface and facilitate the adhesive penetration into enamel microporosities.[22]

The relative humidity in the mouth is considerably high. It is known that this factor has a profound effect on the bond strength values of conventional adhesives (etch and rinse approach) to dental substrates.[23] However, self-etch adhesives are not sensitive to this variable, as demonstrated by an in vitro study.[24] The lower sensitivity to humidity of the self-etch system could possibly justify its superior performance in this clinical trial.

Contrary to this study and the studies of Aljubouri et al,[1] Ireland et al[11] reported an inferior performance of the self-etch adhesive Transbond Plus compared with the Transbond XT. It is likely that the differences in the mode of application of the self-etch system between this study and the study of Ireland et al could have played a role in the different findings. Ireland et al[11] applied the self-etch adhesive following the manufacturer's instructions, ie, brushing it for only 3 seconds on the enamel surface before the application of an air-stream and light curing. Previous reports with self-etch systems have already demonstrated that the agitation of the self-etch adhesives on the enamel surface[25] or its application for double the time recommended[18] can increase the resin-enamel bond strengths and improve the sealing and the etching pattern of enamel.

Keeping in mind the findings of these previous in vitro studies, the self-etch Transbond Plus was applied for 10–15 seconds in this study. This means a three to five times increase in the manufacturer's recommended application time. This could be the reason for the differences observed in this study and in the study of Ireland et al. However, because this study did not aim to evaluate the effect of the priming time of the Transbond Plus on the survival rate, this hypothesis should be evaluated in future clinical and laboratory evaluations.

An ideal orthodontic adhesive should have adequate bond strength while maintaining unblemished enamel.[26] ARI determination shows the cohesive or adhesive nature of the orthodontic bond. Adhesive failures at the enamel surface might be the result of reduced depth of demineralization; therefore, less adhesive remains on the tooth decreasing the time required to clean the enamel surface.[16] Usually, the use of conventional bonding techniques shows mainly cohesive bond failure.[16,27,28] Velo et al[29] and Bishara et al[30] both studied self-etch adhesive bond failures and found adhesive failure rather than cohesive detachment at debond.

Contrary to these aforementioned findings, this study shows that no differences in the frequency of failure modes were observed between the materials. According to Diedrich,[31] the failure mode of the brackets depends, among other factors (cohesive strength of the adhesive, bracket base morphology, etc), on the resin-enamel bond strengths values achieved by the bonding systems. Bonding materials with low–bond strength to enamel tend to show debonding at the adhesive-enamel interface, whereas materials with high enamel-resin bond strength tend to show cohesive failures or adhesive-bracket debonding. As previously mentioned, these two systems (Transbond XT and Transbond Plus) behave similarly with regard to bond strength evaluations[2,5–9] and therefore this finding can explain similar findings concerning the failure modes.

Long-term clinical evaluations are still required to confirm the superiority of the self-etch approach for brackets bonding. A final report on the failure rates of this clinical trial will be reported as soon as the patients reach the end of their treatment period.

CONCLUSIONS

- The highest survival rate was obtained with the self-etch Transbond Plus Self-Etching.
- No difference was observed in the failure modes between the Transbond XT and the Transbond Plus.

ACKNOWLEDGMENTS

The authors of this study are very grateful to 3M Unitek for providing the Transbond Plus Self-Etching Primer used in this clinical study. This study was partially supported by CNPq grants 302552/2003-0 and 305870/2004-1.

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