Effect of saliva contamination on bracket failure with a self-etching primer: A prospective controlled clinical trial

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Introduction: The aim of this study was to evaluate in vivo the effect of saliva contamination at different stages of the bonding procedure on the bond failure rate and the adhesive remaining on teeth after debonding brackets bonded with a hydrophilic self-etching primer (Transbond Plus self-etching primer [TSEP], 3M Unitek, Monrovia, Calif). Methods: This was a prospective controlled clinical trial. The sample consisted of 46 patients with similar treatment plans and mechanotherapies. Stainless steel brackets (n = 531) were bonded with TSEP. The patients were divided into 2 groups: contamination with saliva before TSEP application and contamination with saliva after TSEP application. In both groups, saliva was applied in a split-mouth design. Diagonally opposite quadrants were allocated to either the contaminated group (contamination before [153 teeth] or after [115 teeth] TSEP application) or to the uncontaminated control group (263 teeth). Recording of failed brackets involved only first-time failures, and the observation period was a minimum of 6 months. Results: The chi-squared test showed no significant differences (P = 0.11) in bracket failures between the groups. Kaplan-Meier survival analysis detected no significant differences in the survival rates between the 3 groups (P = 0.51). Most bond failures occurred during the first 3 months. In all 3 groups, the adhesive remaining on teeth after debonding tended to be less than half. Conclusions: These findings suggest that saliva contamination before or after application of self-etching primer does not increase the clinical risk of bond failure. (Am J Orthod Dentofacial Orthop 2010;137:679-83)

Ever since Newman1 bonded brackets directly to tooth enamel, there have been many attempts to determine the causes and to reduce the incidence of bracket loss. Zachrisson2 cited contamination as an important cause of bond failure. The critical moment in the bonding process occurs just after the enamel has been etched; thus, controlling and isolating contamination at that stage is vital.

Oral contaminants can be grouped as follows: macroscopic and intrinsic to the mouth (oral fluids), microscopic and intrinsic (bacteria), extrinsic introduced by the subject (from diet and oral hygiene practices), and extrinsic introduced by the practitioner (lubricants used with rotatory instruments and latex). Much literature deals with contamination by oral fluids. Oonsombat et al3 and Sfondrini et al4 studied contamination from blood; both studies concluded that blood contamination greatly reduces bond strength. Of the oral fluids, saliva is the most common during clinical procedures. One reason why studies have tried to evaluate the effect of saliva on etched enamel is that the enamel, left clean and dry after etching, is a highly energized surface, a circumstance that facilitates the dispersion of polar organic fluids. Silverstone et al5 found that, when enamel has been exposed to saliva for half a second, the saliva can be removed successfully with water, whereas exposure time longer than 1 second allows the deposit of a surface layer that resists washing. They also found that the capacity for saliva contamination is independent of the area of enamel exposed to it. It has also been observed that bond strength values are significantly lower when brackets are bonded with the enamel still damp from saliva than when the enamel had been dried or reetched after contamination.7 It is estimated that saliva contamination reduces bond strength...
by 50%7 or more,8 because it fills the microporosities of the etched enamel, affecting the mechanical retention of the bonding material.

Self-etching adhesives have been developed as one of many attempts to reduce chair time and the number of intermediary procedures.9 In addition, the hydrophilic monomers in self-etching primers could be advantageous in the control of saliva contamination. Chemical reaction of self-etching primers with enamel takes place concomitantly with the chemisorption of the self-etching primers on the enamel surfaces. Phosphoric acid esters can not only decalcify hydroxyapatite, but also chemically adhere to the hydroxyapatite.10 Chemical adhesion could explain their tolerance to moisture. Another possible explanation might be the water in its composition. Water is necessary to activate the self-etching primer and obtain an adequate pH. Several in-vitro studies have evaluated the effect of saliva etching primer and obtain an adequate pH. Several in-vitro studies have evaluated the effect of saliva contamination on bond strength of brackets bonded with self-etching adhesives, with disparate results; for this reason, in-vivo studies are needed to clarify these findings.11-16

Our objectives were to determine in vivo the effect of saliva contamination, introduced at different stages during the bonding process, on both the bond failure rate and the adhesive remaining on teeth for brackets bonded with a self-etching primer.

MATERIAL AND METHODS

Our subjects were patients at the Department of Orthodontics of the Faculty of Medicine and Dentistry at the University of Valencia in Valencia, Spain. The study was approved by the Science and Ethics Committee at Valencia University Hospital. Forty-six patients were selected, all requiring treatment with fixed apparatus according to the following criteria: a malocclusion as symmetrical as possible; teeth free of caries, reconstruction, or enamel disorders; and no antagonistic contact between teeth and brackets and similar projected mechanotherapies.

Before the study, informed consent was obtained from each patient. A total of 531 standard metal brackets (Rocky Mountain Orthodontics, Denver, Colo) were bonded with Transbond Plus self-etching primer (TSEP, 3M Unitek, Monrovia, Calif) according to the manufacturer’s instructions. TSEP was applied to the vestibular surface for 5 seconds with the applicator. Then it was dried with a jet of air. Transbond XT resin (3M Unitek) was applied to the bracket base, which was then placed on the tooth surface and pressed firmly. Excess resin was removed around the bracket with a probe, and it was polymerized by positioning an Ortholux XT lamp (3M Unitek) on each interproximal side for 10 seconds. Ten minutes after bracket bonding, the corresponding arch was positioned. First, we placed a twisted 3-strand archwire (Tri-Flex stainless steel, 0.0155 in, Rocky Mountain Orthodontics) or a 0.012-in stainless steel archwire (Tru-Chrome, Rocky Mountain Orthodontics) to be replaced later by the corresponding sequence of arches.

Distribution of the sample proved to be fairly homogeneous; the numbers of brackets bonded on each type of tooth were similar, with a minimum of 23 brackets cemented to the maxillary canines (4.33%) and a maximum of 32 on the maxillary central incisors (6.2%). The patients were divided into 2 groups: saliva contamination before TSEP application, and saliva contamination after TSEP application. Saliva was applied in both groups by using a split-mouth design. Diagonally opposite quadrants were allocated to either the contaminated group (contamination before,153 teeth, or after TSEP application, 115 teeth) or to the uncontaminated control group (263 teeth). Bracket bond failures were recorded only for first-time failures, and the observation period was a minimum of 6 months.

The patient’s own saliva was used for contamination. When the bond area had been isolated, a cotton swab soaked up saliva from the area around the Stenon duct opening. Patients were asked not to eat or drink for an hour before their appointment to ensure that saliva was not stimulated, and they were also asked to clean their teeth before bonding. Once saliva had been obtained, the swab was applied to the vestibular surface of the tooth so that it became completely contaminated.

When brackets failed, the adhesive remnant index (ARI) score was calculated according to the criteria of Årtun and Bergland17: 0, no adhesive on the tooth; 1, less than half of the adhesive on the tooth; 2, more than half of the adhesive on the tooth; and 3, all adhesive left on the tooth, with an impression of the bracket base.

Only first-time failures were recorded, and the observation period was a minimum of 6 months (range, 6-16 months).

Statistical analysis

Data were analyzed with the SPSS statistical program for Windows (version 14.0, SPSS, Chicago, Ill).

<table>
<thead>
<tr>
<th>Group</th>
<th>Brackets (n)</th>
<th>Failures (n)</th>
<th>Failure rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>263</td>
<td>16</td>
<td>6.08</td>
</tr>
<tr>
<td>Contamination before</td>
<td>153</td>
<td>16</td>
<td>10.46</td>
</tr>
<tr>
<td>Contamination after</td>
<td>115</td>
<td>5</td>
<td>4.35</td>
</tr>
</tbody>
</table>

The chi-squared test found no significant differences ($P = 0.11$) in bracket failures between the groups.
The failure rates and ARI scores over the 6-month period were analyzed with the chi-squared test. Significance was predetermined at $\alpha = 0.05$.

Bracket survival rate was analyzed with the Kaplan-Meier survival analysis by using the Breslow statistic at $\alpha = 0.05$ level of significance. In order not to lose information about brackets observed beyond the 6-month point, the Kaplan-Meier test was carried out with 16 months as the observation period.

**RESULTS**

Table I shows the numbers and rates of bracket failures over 6 months. The chi-squared test showed no significant differences ($P = 0.11$) in bracket failures between the groups.

The Kaplan-Meier survival analysis detected no significant differences in bracket survival rates among the 3 groups ($P = 0.51$). The 3 groups had the same pattern, with more bracket failures during the first 3 months; the survival rate was approximately 95% (Fig).

The results for the ARI are shown in Table II. The chi-squared test found no significant differences ($P = 0.62$). However, as the expected frequencies in some cells were less than 1, this result should be interpreted with some caution. When the chi-square test is applied, the expected frequencies should be less than 1 in each cell, whereas more conservative authors recommend less than 5.18

**DISCUSSION**

We chose the split-mouth design for this in-vivo study because of the 2 advantages of time saving and fewer subjects required. Moreover, with this design, it was unnecessary to compare treatments between patients, since each patient was compared with himself or herself.

This design was studied by Hujoel and Loesche19 in periodontal research; they found that asymmetrical distribution of periodontal disease can endanger the efficiency of such studies. However, in our study, asymmetry was not a problem because the adhesive was applied symmetrically in each group.

In in-vivo studies, Sunna and Rock20 and Linklater and Gordon21 obtained results for bracket failure rates of 6.6% and 6.34%, respectively; these correspond to the average rate of bracket failure in clinical practice with the conventional technique. Our study obtained a similar percentage (6.08%), suggesting that the use of self-etching adhesives without contamination produces results close to this average.

The results showed no significant differences between bracket bond failures for the groups with and without saliva contamination.
The absence of significant differences suggests that, in clinical practice, when the practitioner knows that there is no contamination, it might be unnecessary to apply a second layer of adhesive as recommended by the manufacturer.

We have not found any in-vivo studies of contamination with which we could compare our results, so we can compare them only with in-vitro studies of the same product. These results are fairly disparate; this might be due to the varying methods used by other authors. The reason could be the differences in force distribution among specimens caused by differences in mounting and surface curvature of the experimental teeth, as reflected in the large standard deviations in the bond strength of specimens in the same experimental group.

As in our study, Zeppieri et al. found no significant differences between the 3 groups, whereas Larmour and Stirrups found significant differences between contamination before TSEP application group and their control group. Cacciafesta et al. found significant differences between the control group and the group with contamination after TSEP application, and Townsend and Dunn found significant differences between the control group and the group with contamination before TSEP application, and between the control group and the group with contamination after TSEP application.

Most bracket failures occurred during the first 3 months after bonding, a time that often coincides with increased shear forces resulting from increased overbite, with increased gyroversion that can provoke excessive tension when the arch is bonded, or with the outcome of defective or incorrect bonding techniques. This suggests that, once the third month has passed, the life expectancy of a bracket bonded with this adhesive is fairly high. In a previous in-vivo study, O’Brien et al. evaluated bond failure with the conventional acid-etch technique, finding that 13% of brackets failed during the first 3 months, but Sunna and Rock found no significant differences in the timing of bracket bond failure.

As for ARI scores after debonding, the 3 groups tended to behave similarly, with less than half of the adhesive on teeth; this agrees with the results of previous in-vitro studies. Similar ARI scores among the groups would confirm that self-etching primers are not affected by saliva contamination and do not allow the tags to be blocked by saliva. Any surface contamination increases the tendency for failure in the enamel-adhesive interface because of weakened mechanical retention caused by blocking the tags produced by etching, so that minimal amounts of adhesive remain on the tooth surface after failure. The similar ARI scores after failure of the brackets in the experimental quadrants would confirm that saliva contamination can be tolerated.

In addition, this result shows an advantage, since it is well known that, to eliminate adhesive remnants, part of the enamel is inevitably removed as well. Several authors concluded that, with a low-speed tungsten-carbide bur, a loss of at least 7.4 μm is produced. For this reason, the less adhesive left on the enamel after bracket debonding, the lower the possibility of causing lesions from cleaning procedures.

CONCLUSIONS

1. Self-etching adhesives, whether contaminated or not, have a fairly low percentage of bond failure, at least under the conditions of this study.
2. Saliva contamination, either before or after application of the self-etching primer, does not cause a significant increase in bond failures.
3. The probability of bond failure is greater immediately after bonding and during the first 3 months of bracket life.
4. When brackets fail, they tend to leave more adhesive on the bracket than on the tooth.

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REFERENCES