Effect of Different Methods for Decontaminating Tooth Enamel After Contact With Blood Before Bonding Orthodontic Buttons

Matheus Melo Pithon, PhD,* Vanessa Oliveira Batista,† and Natalli Cardoso Cafseiro D’el Rey‡

Purpose: To evaluate the best method for decontaminating tooth enamel contaminated by contact with blood before bonding orthodontic buttons.

Materials and Methods: The labial surfaces of 195 bovine incisors initially received prophylaxis, followed by 37% phosphoric acid etching, adhesive application, and light polymerization. After this, the labial surfaces of all teeth were contaminated with blood. The teeth were then randomly divided into 13 groups (n = 15), comprising the control group (treated according to the manufacturer’s recommendations) and 12 experimental groups treated by the following decontamination methods: group 1, no decontamination; group 2, washing with distilled water; group 3, washing with physiologic solution; group 4, jets of air; group 5, gauze; group 6, cotton wool; group 7, distilled water plus jets of air; group 8, distilled water plus gauze; group 9, distilled water plus cotton wool; group 10, physiologic solution plus jets of air; group 11, physiologic solution plus gauze; and group 12, physiologic solution plus cotton wool.

Results: No statistical differences were shown between the control group and groups 4, 7, 10, and 11 (P > .05). The lowest bond strength values were shown in group 1, in which no decontamination was performed, and groups 6 and 12, which were decontaminated with cotton wool and physiologic solution plus cotton wool, respectively.

Conclusions: The best method of decontaminating enamel contaminated with blood is washing with physiologic solution, followed by drying with jets of air and gauze or drying with jets of air only.

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Permanent teeth play an important role in establishing and maintaining the form and function of the dentition, and their presence in the dental arch is fundamental for ensuring balanced, dynamic occlusion, as well as facial esthetics and harmony. Thus, considering their impor-

tance in the dental arch, when one is confronted with an impacted permanent tooth, every effort should be made to retain the tooth.1 Interdisciplinary treatment involving the orthodontist and surgeon is required to expose and align impacted teeth.2 However, when the only option for performing traction is to bond the orthodontic accessories at the time of surgery, it is difficult to maintain ideal working conditions.3,4 The materials most used for bonding orthodontic accessories are orthodontic composites, which demand completely dry surfaces to obtain clinically acceptable mechanical resistance.5,6 However, during the act of surgery, clinical conditions often do not allow ideal isolation of the bonding site, and this may cause premature treatment failure, making it necessary to perform a new surgical intervention.7,9

The properties of a composite may be harmed by various intraoral factors, such as the high degree of humidity inside the oral cavity, aging of the tooth,
dental caries, and saliva and/or blood at the bonding site. At the time of bonding, the acid etching process dissolves some of the crystals of the enamel prism, making the surface appropriate for micromechanical retention. However, when bonding areas are momentarily contaminated with blood, an organic pellicle forms, which diminishes enamel porosity, reduces tag formation, and makes it difficult for light-polymerized compounds to adhere. In contrast, studies have shown that contamination of the area with water does not affect the bonding capacity.

In an endeavor to overcome enamel contamination, water and air spray are used. Some studies have reported that the oral cavity fluids are resistant to washing with water, but little is known about the effects of other methods of decontamination on the bond strength of orthodontic accessories to enamel.

The purpose of this study was to evaluate the effects of different methods of contamination on the shear bond strength of orthodontic buttons used to perform traction of impacted canines to enamel previously contaminated with blood, in addition to verifying the null hypothesis that the strength of the adhesive bond measured using the shear bond strength and adhesive remnant index (ARI) is equal regardless of the decontamination technique. The specific aim of the study was to evaluate the shear bond strength and ARI of orthodontic buttons bonded to an enamel surface that was previously contaminated with blood and decontaminated by different methods, such as distilled water, physiologic solution, jets of air, gauze, and cotton wool, as well as combinations of these methods.

Materials and Methods

SAMPLE

In this in vitro evaluation, 195 permanent bovine mandibular incisors were used. The inclusion criterion was that the teeth be intact, that is, without cavitation caused by caries and/or the extraction process. The teeth were cleaned, stored in a 10% formol solution in a glass receptacle, and kept in a refrigerator at approximately 6°C.

STUDY DESIGN (CROSS-SECTIONAL)

The teeth were embedded in rigid polyvinyl chloride rings (Tigre, Joinville, Brazil) with acrylic resin (Clássico, São Paulo, Brazil) so that only their crowns were exposed. During embedment, the labial surfaces of these crowns were placed perpendicular to the base of the die with the aid of a 90° set square made of glass, to ensure correct mechanical testing. After polishing of the resin, all the sets were stored in distilled water and again placed in the refrigerator.

Table 1. EXPERIMENTAL GROUPS ACCORDING TO DECONTAMINATION PROCESSES PERFORMED DURING IN VITRO ANALYSIS

<table>
<thead>
<tr>
<th>Groups</th>
<th>Washing</th>
<th>Drying</th>
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<tbody>
<tr>
<td></td>
<td>Distilled Water</td>
<td>Physiologic Solution</td>
</tr>
<tr>
<td>1</td>
<td>—</td>
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<tr>
<td>2</td>
<td>Yes</td>
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<tr>
<td>3</td>
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<td>Yes</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
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<td>6</td>
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<tr>
<td>7</td>
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<td>—</td>
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<td>8</td>
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<td>9</td>
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<td>10</td>
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<td>Yes</td>
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<tr>
<td>11</td>
<td>—</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>—</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The labial surfaces of the teeth received prophylaxis with a rubber cup (Viking; KG Sorensen, Barueri, Brazil), extra-fine pumice stone (S.S. White, Juiz de Fora, Brazil), and distilled water for 15 seconds. After this, they were washed with air spray/distilled water and dried with an oil- and humidity-free jet of air for the same length of time.

Next, 37% phosphoric acid etching was performed (FGM, Joinville, Brazil) for 30 seconds, followed by washing with water and drying with jets of air for the same period. A thin coat of primer (Transbond XT; 3M Unitek, Monrovia, CA) was applied and light polymerized for 10 seconds.

VARIABLES

The experimental teeth were contaminated with human blood, with the aid of an applicator brush, and randomly divided into 12 groups (n = 15) according to the decontamination method used, as shown in Table 1.

After decontamination, orthodontic buttons were bonded with composite (Transbond XT). Excess composite was removed, and light polymerization was performed for 40 seconds with an XL 1500 appliance (3M Dental Products, Monrovia, CA) with a lamp intensity of 400 mW/cm², regularly checked with a radiometer (Demetron, Danbury, CT).

In the control group, no contamination or decontamination procedure was performed, and for bond application, only the manufacturer’s instructions were followed.
DATA COLLECTION METHODS

After bonding, the test specimens were stored in artificial saliva and kept in an oven for 24 hours, at a temperature of 37°C. The shear bond strength test was performed in a universal mechanical test machine (AME-2kN; Filizola, São Paulo, Brazil), operating at a speed of 0.5 mm/min, through the active tip of a chisel. The shear bond strength results were obtained in kilogram-force, transformed into Newton, and divided by the bracket base area to provide results in Megapascal.

After we performed the shear bond strength test, the labial surface of each test specimen was evaluated under a stereoscopic loupe (Carl Zeiss, Göttingen, Germany) at 16× magnification to quantify the ARI, in accordance with the criteria recommended by Årtun and Bergland15: 0, no amount of composite adhered to enamel; 1, less than half the composite adhered to enamel; 2, more than half the composite adhered to enamel; and 3, all the composite adhered to enamel.

DATA ANALYSES

The shear bond strength test results were submitted to analysis of variance and, afterward, to the Tukey test to compare the control with the other treatments. To evaluate the ARI scores, the Kruskal-Wallis test was used.

Results

The highest values were attained by the control group, in which all the material manufacturer’s instructions were strictly followed. This group showed no statistical differences (P > .05) from groups 4 (decontaminated with jets of air), 7 (decontaminated with distilled water plus jets of air), 9 (decontaminated with distilled water plus cotton wool), 10 (decontaminated with physiologic solution plus jets of air), and 11 (decontaminated with physiologic solution plus gauze) (Table 2).

The lowest bond strength values were found in groups 1 (without decontamination), 6 (decontaminated with cotton wool only), and 12 (decontaminated with physiologic solution plus cotton wool) and presented no statistical differences between them (P > .05).

Regarding ARI, the control group and groups 7 and 10 showed higher mean values, showing greater composite bond to enamel. The other groups showed low bond strength values, showing failure of the composite bond to enamel (Table 2).

Discussion

The purpose of this study was to evaluate the effects of different methods of decontamination of enamel that was previously contaminated with blood on the shear bond strength of orthodontic buttons used to perform traction of impacted canines, in addition to verifying the null hypothesis that the strength of the adhesive bond measured by use of the shear bond strength and ARI is equal regardless of the decontamination technique. The specific aim of the study was to evaluate the shear bond strength and ARI of orthodontic buttons bonded to an enamel surface that was previously contaminated with blood and then decontaminated by different methods, such as distilled water, physiologic solution, jets of air, gauze, and cotton wool, as well as combinations of these methods.

The lowest bond strength values were found in the group that was not decontaminated (group 1). In the group decontaminated with cotton wool only (group 6) and that in which decontamination was performed with the combination of physiologic solution and cotton wool (group 12), the ARI results were the highest. In turn, the groups in which decontamination was performed with distilled water combined with jets of air (group 7), physiologic solution combined with jets of air (group 10), and physiologic solution plus gauze (group 11) were the groups that showed the best results. The null hypothesis was not confirmed, because the shear bond strength values and ARI differed with the use of different decontamination methods.

When interpreting the remaining results, we verified that for the decontamination methods using only distilled water (group 2), physiologic solution (group 3), or gauze (group 5) or the combination of distilled water and cotton wool (group 9), poor results were shown in comparison with the control group. Nevertheless, the values obtained were better than those found in the group that was not decontaminated (group 1) and the groups decontaminated with cotton wool (group 6) and with the combination of physiologic solution and cotton wool (group 12). The groups decontaminated only with jets of air (group 4) and with the combination of distilled water and gauze presented intermediate bond strength values (group 8).

As previously mentioned, when the tooth surfaces were contaminated and no decontamination was performed, there was a significant fall in bond strength values, presenting a mean of 3.75 MPa. This emphasizes the need for prior enamel decontamination when the material chosen for bonding is Transbond XT, because this material has no affinity for moist surfaces. This bond strength value is lower than the clinically accepted value, which is in agreement with previous investigations.3,11,12,16,17

In a study on dry surfaces, a bond strength of 26.5 MPa was found, differing from the findings of Özto-
<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (SD)</th>
<th>Significance</th>
<th>Mean (SD)</th>
<th>Significance</th>
</tr>
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<tbody>
<tr>
<td>Control</td>
<td>26.5 (15.7)</td>
<td></td>
<td>1.4 (0.79)</td>
<td></td>
</tr>
<tr>
<td>1 (no decontamination)</td>
<td>3.752 (1.34)</td>
<td></td>
<td>0.26 (0.62)</td>
<td></td>
</tr>
<tr>
<td>2 (distilled water)</td>
<td>7.28 (6.48)</td>
<td></td>
<td>0.06 (0.28)</td>
<td></td>
</tr>
<tr>
<td>3 (physiologic solution)</td>
<td>8.35 (7.32)</td>
<td></td>
<td>0.26 (0.62)</td>
<td></td>
</tr>
<tr>
<td>4 (jets of air)</td>
<td>14.14 (12.02)</td>
<td></td>
<td>0.4 (0.66)</td>
<td></td>
</tr>
<tr>
<td>5 (gauze)</td>
<td>7.74 (4.17)</td>
<td></td>
<td>0.54 (4.4)</td>
<td></td>
</tr>
</tbody>
</table>

prak et al\(^9\) (15.28), who used the same adhesive material. In contrast, in the groups in which the enamel was contaminated with blood, the results were close to the value of 3.75 MPa obtained in our study (3.08).

However, the results of a study conducted by Hobson et al\(^1\) showed that the bond strengths to enamel contaminated with water or human blood were higher than the values found in this study, being 12.89 MPa and 11.16 MPa, respectively. The variability in the results may be attributed to the use of a different primer, Transbond MIP (3M Unitek), which has hydrophilic characteristics.

According to Sfondrini et al\(^16\) and Brauchli et al\(^17\), the explanation for the reduction in shear bond strength lies in the chemical composition of blood, which interferes in the links between the resin and adhesive by forming a physical barrier that prevents tag formation, leading to a reduction in mechanical retention.

Various studies have analyzed shear bond strength in a dry, contaminated environment; nevertheless, there is a scarcity of studies that evaluate the influence of decontamination methods on bond strength.

Certainly, the complete repetition of all the bonding steps would be the best way to obtain a better bond after enamel has been contaminated. Neverthe-

less, according to Brauchli et al\(^17\), repeating etching may cause even more enamel loss. Therefore, when a decontamination procedure is performed, it will minimize the possibility of loss of adhesiveness occurring.

In our study, when the decontamination method was washing with distilled water only (group 2) or physiologic solution only (group 3), the bond strength values found were low, 7.28 and 8.35 MPa, respectively, and were statistically lower than those of the control group.

For the decontamination methods in which only drying with air (group 4), gauze (group 5), or cotton wool (group 6) was performed after contamination, the results were also low, showing differences in comparison with the control group.

When cotton wool was used in decontamination after washing with physiologic solution (group 12), the value obtained was close to that found in the group contaminated with blood (group 1) and the method was considered inadequate.

However, when washing with physiologic solution and drying with a jet of air (group 10) (mean, 21.78 MPa) or gauze (group 11) (mean, 20.69 MPa) and when washing with distilled water and drying with a jet of air (group 7) (mean, 20.53 MPa), bond strengths close to those of bonding the buttons in a dry envi-

### Table 2. (CONTINUED)

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (SD) Significance</th>
<th>ARI Mean (SD) Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 (cotton wool)</td>
<td>4 (1.75)</td>
<td>0.13 (0.38)</td>
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<tr>
<td>7 (distilled water plus jets of air)</td>
<td>20.53 (14.76)</td>
<td>1.46 (0.52)</td>
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<tr>
<td>8 (distilled water plus gauze)</td>
<td>11.66 (13.91)</td>
<td>0.33 (0.65)</td>
</tr>
<tr>
<td>9 (distilled water plus cotton wool)</td>
<td>8.41 (12.30)</td>
<td>0.13 (0.57)</td>
</tr>
<tr>
<td>10 (physiologic solution plus jets of air)</td>
<td>21.78 (14.98)</td>
<td>1 (0.85)</td>
</tr>
<tr>
<td>11 (physiologic solution plus gauze)</td>
<td>20.69 (11.87)</td>
<td>0.86 (0.57)</td>
</tr>
<tr>
<td>12 (physiologic solution plus cotton wool)</td>
<td>3.6 (1.6)</td>
<td>0.26 (0.62)</td>
</tr>
</tbody>
</table>

Decontaminating Tooth Enamel

In the studies of Brauchli et al., a mean bond strength of 25.06 MPa was found in the control group. In the group contaminated with blood, the mean was 4.88, and in the group contaminated with blood and decontaminated with water, a mean of 21.37 MPa was obtained. These results corroborate the findings of our study.

Groups 4, 7, 8, 10, and 11, which were submitted to different methods of decontamination, presented higher bond strength values than the minimum for orthodontic accessories bonded to enamel, suggested by Reynolds. According to this author, a bond strength of 6 to 8 MPa is sufficient to bear the forces of mastication and orthodontic mechanics and, therefore, is adequate for the majority of orthodontic clinical requirements. Groups 2, 3, 5, and 9 presented values within the limit defined by Reynolds. The others showed a lower mean and are inadequate for use in clinical practice.

When we evaluated the quantity of adhesive remaining, using the ARI, the results obtained in the control group, group 7, and group 10 were observed to be equal to or higher than 1, whereas values below 1 were obtained in the other groups; therefore, our results were similar to those shown in other studies.

The strong points of this study are the originality and clinical importance of the study, because knowing the best method of decontamination will facilitate transsurgical bonding procedures and reduce the clinical time spent. The weak point is the laboratory design of the study. Nevertheless, clinical studies are necessary to establish whether the events that occurred in the laboratory can be extrapolated to the clinical situation.

On the basis of the data found in our study, we conclude that the best method of decontaminating enamel contaminated with blood before bonding orthodontic buttons is washing with physiologic solution or distilled water and drying with jets of air or gauze. Future plans along this line of research will involve conducting clinical evaluations of the best method of decontamination.

References