Marginal Adaptation of Class V Restorations with Current-Generation Dentin-Bonding Agents: Effect of Different Dentin Surface Treatments

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Abstract

This study sought to assess the use of chlorhexidine with several excipients as a dentin surface treatment and its effect on marginal adaptation of class V restorations with current-generation dentin bonding agents. A total of 120 human third molars were selected and allocated into 12 groups, with standardized buccal class V restorations randomly divided into preconditioned dentin rinsed with: water; water + chlorhexidine; ethanol; or ethanol + chlorhexidine. After rinsing of dentin (previously conditioned with 35% phosphoric acid) with the test solutions, the Adper single bond 2, prime and bond 2.1, and Excite bonding systems were applied randomly. Restorations were performed with Filtek™ Z350 XT composite resin. The resulting specimens were subjected to thermal and mechanical load cycling. Quantitative analysis of marginal adaptation was performed on epoxy replicas by means of scanning electron microscopy. Results were assessed by means of the Kruskal-Wallis test (percentages of continuous margins) and Wilcoxon test (differences between percentages of continuous margins before and after thermal cycling and mechanical loading), at a significance level of p < 0.05. Outcomes in the chlorhexidine-treated groups were not superior to those obtained with other treatments.

Keywords: Dentin-bonding agents, Marginal adaptation, Chlorhexidine, Ethanol, Scanning electron microscopy.

properties that may affect long-term survival of the adhesive-
restoration interface. To address this issue, a new
technique known as ‘ethanol-wet bonding’ was developed,
in which ethanol is used instead of water. Theoretically, use
of this technique would yield a less hydrophilic environment,
keeping the collagen matrix expanded and allowing monomers to permeate through to the interfibrillary spaces. Some aspects have yet to be validated, such as the use of a combination of ethanol and chlorhexidine, as both solutions have been shown to produce favorable outcomes in terms of the resin-dentin bond.

Furthermore, the use of chlorhexidine on demineralized
dentin may increase its surface free energy to levels resembling
those of enamel, thus enhancing the wettability of
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those of enamel,18,19 thus enhancing the wettability of
dentin.9,10,15,16,27 The higher immediate bond strength values observed
in chlorhexidine-treated groups.20,21 Studies are currently
being conducted to assess whether interventions designed
to minimize the effects of enzymatic and hydrolytic degra-
dation of the resin-dentin bond (whether in combination
or alone) can interfere with the formation and mechanical
stability of the resin-dentin bond in carious teeth.

In view of the high rate of failure of dental restorations,
which is more common in the posterior teeth than in the
anterior teeth,22,23 dental practitioners must be mindful of
the conditions to which restorations are exposed, including
ambient temperature and mechanical load cycles associated
with mastication24-26 and understand the contributions of
each potential mechanism of degradation so as to ensure a
better resin-dentin bond and a stable adhesive interface.27

Within this context, the present article seeks to investi-
gate the influence of chlorhexidine, when used as an adjuvant
to the process of bonding to the dentin substrate on marginal
adaptation after thermal cycling and scanning electron
microscope analysis.

MATERIALS AND METHODS

A total of 120 noncarious human third molars were ext-
ected and stored in 1% thymol at 4°C until use. All patients
were provided information on the study and gave written
informed consent for use of their teeth. The study was
approved by the UNESP Araraquara School of Dentistry
Research Ethics Committee with judgement number 52/11.

The teeth were allocated into 12 groups of 10 specimens
each. A standardized class V cavity (depth 2.0 mm, cervico-
incisal length 2.0 mm, mesiodistal length 4.0 mm) was
created on the buccal surface of each specimen with the aid
of a round diamond bur. Burs were replaced after preparation
of four cavities.

Surface Treatment

Prepared teeth were randomly divided into subgroups accor-
ding to the dentin surface treatment applied. All enamel and
dentin surfaces were conditioned with 35% phosphoric acid
(Ultradent Products Inc., South Jordan, Utah, USA) for 30
and 15 seconds respectively, rinsed in water for 10 seconds,
and dried with absorbent paper.

- **Conditioned dentin rinsed with water:** Conditioned den-
tin was kept moist and the bonding agent was applied
without any further surface treatment.
- **Conditioned dentin rinsed with chlorhexidine in water:**
Conditioned dentin was treated with 20 µl of a solution of
1% chlorhexidine diacetate in water (0.25 gm/25 ml),
which was kept in place for 60 seconds and then dried off
with absorbent paper.
- **Conditioned dentin rinsed with ethanol:** Conditioned
dentin was treated with 20 µl of 100% anhydrous ethanol
(JT Baker, Mallinckrodt SA, Xalostoc, Mexico), which
was kept in place for 60 seconds and then dried off with
absorbent paper.
- **Conditioned dentin rinsed with chlorhexidine in ethanol:**
The smear layer-coated dentin surface was conditioned
and, under similar moisture conditions, treated with
20 µl of a compounded solution of 1% chlorhexidine dia-
cetate in anhydrous ethanol (0.19 gm/25 ml). The solu-
tion was kept in place for 60 seconds and then dried off
with absorbent paper.

Bonding Procedure

After treatment of conditioned dentin with the test solutions,
the teeth were randomly subdivided by surface treatment
type and the dentin adhesive systems Adper single bond 2
(3M ESPE, St Paul, MN, USE), prime and bond 2.1 (Dents-
ply, Milford, DE, USA), and Excite (IvoclarVivadent,
Schaan, Liechtenstein) were applied randomly in accordance
with manufacturer instructions.

After the bonding procedure, cavities were restored with
Filtek™ Z350 XT composite resin, shade A3 (3M ESPE,
St Paul, MN, EUA). The composite resin was placed incre-
mentally into the cavity—one portion onto the axial wall,
one onto the mesial wall, and one onto the distal wall and
each increment was light-cured for 20 seconds.

Following curing, restorations were finished and polished
with Sof-Lex™ Pop-On tooth polishing discs (3M ESPE)
and a silicon carbide brush. The restored teeth were then
stored in water at 37°C in a dark area.

After specimens had been in storage for 1 week, im-
pressions of the external margins of each restoration were
obtained using a vinyl polysiloxane impression material
Results are shown in Table 1. In specimens restored with the excite adhesive system, there were no differences in dentin or enamel continuous margin between the distinct surface treatment subgroups. However, on analysis of the effects of thermal cycling, significant differences in enamel were observed in specimens treated with ethanol and in those treated with chlorhexidine. Significant differences in dentin were found in the chlorhexidine and ethanol + chlorhexidine-treated groups.

In specimens restored with the Adper single bond system, there were no differences in enamel between any of the surface treatment subgroups (Figs 1A and B). In dentin, significant differences were found in the ethanol, ethanol + chlorhexidine, and chlorhexidine-treated groups, both before and after thermal cycling.

The greatest changes in external margin after thermal cycling were found in specimens restored with the prime and bond 2.1 system, both in dentin and in enamel (Figs 1C and D).

**DISCUSSION**

As shown in Table 1, in specimens restored with the Excite adhesive system, there were significant differences before and after thermal cycling in the ethanol-treated and chlorhexidine-treated groups in enamel and in the chlorhexidine and ethanol + chlorhexidine-treated groups in dentin. Analysis of findings for the aforementioned groups in enamel showed that median values had relatively narrow ranges, in the region of 93.50. However, comparative analysis of results that differed significantly with those that did not in the

<table>
<thead>
<tr>
<th>Bonding agent</th>
<th>Treatment</th>
<th>Continuous margin, enamel (%)</th>
<th>Continuous margin, dentin (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Precycling</td>
<td>Postcycling</td>
</tr>
<tr>
<td>Excite</td>
<td>Water</td>
<td>98.50 (± 2.28)Aa</td>
<td>93.65 (± 2.81)Aa</td>
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<td></td>
<td>Ethanol</td>
<td>99.00 (± 2.23)Aa</td>
<td>93.50 (± 8.52)Ab</td>
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<tr>
<td></td>
<td>CLX</td>
<td>95.50 (± 2.28)Aa</td>
<td>93.95 (± 2.34)Ab</td>
</tr>
<tr>
<td></td>
<td>Ethanol + CLX</td>
<td>99.00 (± 2.09)Aa</td>
<td>93.50 (± 6.73)Aa</td>
</tr>
<tr>
<td>Adper single bond</td>
<td>Water</td>
<td>96.15 (± 7.13)Aa</td>
<td>86.80 (± 7.15)Aa</td>
</tr>
<tr>
<td></td>
<td>Ethanol</td>
<td>97.65 (± 6.07)Aa</td>
<td>93.40 (± 11.72)Aa</td>
</tr>
<tr>
<td></td>
<td>CLX</td>
<td>98.50 (± 1.94)Aa</td>
<td>96.00 (± 1.33)Aa</td>
</tr>
<tr>
<td></td>
<td>Ethanol + CLX</td>
<td>99.35 (± 1.59)Aa</td>
<td>93.60 (± 7.30)Aa</td>
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<tr>
<td>Prime and bond</td>
<td>Water</td>
<td>100.00 (± 0.87)Aa</td>
<td>83.50 (± 5.24)Ab</td>
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<tr>
<td></td>
<td>Ethanol</td>
<td>98.00 (± 0.99)Ba</td>
<td>84.25 (± 7.59)Ab</td>
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<tr>
<td></td>
<td>CLX</td>
<td>95.85 (± 8.45)Ba</td>
<td>83.45 (± 13.09)Ab</td>
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<tr>
<td></td>
<td>Ethanol + CLX</td>
<td>89.65 (± 5.81)Ba</td>
<td>79.45 (± 7.17)Ab</td>
</tr>
</tbody>
</table>

CLX: Chlorhexidine; Values sharing the same superscript uppercase letters are not significantly different from each other (Kruskal-Wallis test with Dunn’s post-hoc test, p < 0.05) in terms of different materials. Values sharing the same superscript lowercase letters are not significantly different from each other (Wilcoxon test with Dunn’s post-hoc test, p < 0.05) in terms of the effects of thermomechanical cycling on each material and surface (enamel or dentin)
dentin groups suggests that the combination of chlorhexidine and water may have somehow compromised the interaction between the excite bonding agent and the dentin surface. Chlorhexidine diacetate may undergo adsorption at the dentin surface, which would be a desirable feature from the standpoint of prolonged protection. However, adsorption of chlorhexidine to exposed collagen can affect surface wetting properties, which may have had a deleterious effect on the excite adhesive system. Individual comparisons of the different surface treatments in enamel and in dentin showed no significant differences.

The greatest changes in external margins after thermal cycling were observed in the prime and bond 2.1 group, both in dentin and in enamel, with the exception of the water-treated dentin subgroup. This poorer performance of the prime and bond 2.1 system is explained by the presence of acetone in its chemical composition. Due to its solubility pattern, acetone has a lower hydrogen-bonding capacity than that found among peptides. When applied to an expanded matrix in the presence of water, solvents with such lower capacity do not produce re-expansion of the matrix, but rather collapse, which would explain the poorer performance of acetone-based adhesive systems as compared with ethanol/water-based ones. These relationships among bonding agents, their solvents (and water), and the demineralized matrix explain, e.g. the superior performance of ethanol/water-based adhesives as compared with acetone-based bonding agents.

Analysis of the effects of the Adper single bond 2 system on the dentin substrate showed statistically significant differences in chlorhexidine-treated specimens, before (94.10 ± 4.15) and after cycling (87.60 ± 2.01). Despite this difference, median values were higher as compared with those of other surface treatment groups and effects of thermal cycling. In previous studies, chlorhexidine treatment of dentin demineralized with phosphoric acid prior to application of a bonding agent led to preservation of the integrity of collagen within the hybrid layer over time and acted as a metalloproteinase inhibitor. Consequently, it might help maintain the stability of adhesive binding to dentin over time. Therefore, in vitro and in vivo studies have demonstrated that use of chlorhexidine after acid conditioning and before bonding agent application successfully enhances the durability of the resin-dentin bond. As the efficiency of infiltration of adhesive resin into the demineralized zone is unpredictable, practitioners must anticipate that, under normal bonding conditions, cavities will always contain exposed collagen fibrils susceptible to the effects of MMPs. Within this context, chlorhexidine acted as an additional mechanism to protect the resin-dentin bond.

The results of this project are somewhat inconclusive with respect to the use of chlorhexidine, as it was not found to be superior on comparison with other dentin surface treatments. Nevertheless, the stability of chlorhexidine-treated teeth has been reported in the literature.
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REFERENCES


