Degradation of resin-dentin bonds of etch-and-rinse adhesive system to primary and permanent teeth

Abstract: The aim of this in vitro study was to compare the degradation of resin-dentin bonds of an etch-and-rinse adhesive system to primary and permanent teeth. Flat superficial coronal dentin surfaces from 5 primary second molars and 5 permanent third molars were etched with phosphoric acid and bonded with an adhesive system (Adper Single Bond 2, 3M ESPE). Blocks of resin composite (Z250, 3M ESPE) were built up and the teeth sectioned to produce bonded sticks with a 0.8 mm² cross-sectional area. The sticks of each tooth were randomly divided and assigned to be subjected to microtensile testing immediately (24 h) or after aging by water storage (6 months). Data were analyzed by two-way repeated measures ANOVA and Tukey post hoc test (α = 0.05). Failure mode was evaluated using a stereomicroscope (400×). Microtensile values significantly decreased after the 6 months aging, independent of the dentin substrate. In 24 h, the values obtained to primary dentin were lower compared with permanent dentin. This difference was not maintained after aging. Adhesive/mixed failure was predominant in all experimental groups. In conclusion, degradation of resin-dentin bonds of the etch-and-rinse adhesive system occurred after 6 months of water storage; however, the reduction in bond strength values was higher for permanent teeth.

Descriptors: Dentin; Longevity; Tensile Strength; Tooth, Deciduous; Dentition, Permanent.

Introduction

Traditionally, knowledge acquired in laboratory or in vivo studies using permanent teeth has been extrapolated to primary teeth, since the same bonding protocol is indicated for both substrates, despite chemical and micromorphological differences.1,2

It has been reported that the hybrid layers produced in primary teeth were approximately 25%–30% thicker than those produced in permanent dentin using identical acid etching time. This indicates that primary dentin is more reactive to acid etching due to the lower mineral content.3,4 Consequently, the lack of complete infiltration of adhesive resin into previously demineralized dentin creates a zone more prone to degradation,5 which may be more pronounced in primary dentin.

Although several studies have evaluated the immediate bond strength of simplified adhesive systems to permanent and primary dentin, the re-
sults obtained are still controversial. While some studies have shown lower bond strength in primary dentin, others have found similar or even superior performance of the adhesive systems in primary dentin. Moreover, to the best of our knowledge, this is a pioneering investigation that has evaluated long-term performance of etch-and-rinse adhesive system to permanent and primary dentin.

Therefore, this in vitro study aimed to compare the degradation of resin-dentin bonds of an etch-and-rinse adhesive system to primary and permanent teeth.

Methodology
Tooth selection and preparation
Ten sound human teeth, consisting of 5 primary second molars and 5 permanent third molars were collected after the patients’ informed consent had been obtained under a protocol reviewed and approved by the Institutional Ethics Board. The teeth were disinfected in 0.5% aqueous chloramine and stored in distilled water at 4°C until use.

The occlusal enamel was removed with a water-cooled diamond saw in a cutting machine (Labcut 1010, Extec Co., Enfield, USA) to obtain flat dentin surfaces. The surrounding enamel was also removed with a diamond bur (#3195, KG Sorensen, Barueri, Brazil) in a high-speed handpiece with water spray. The specimens were carefully examined under a stereomicroscope at 30× magnification to confirm the absence of enamel islets. The exposed occlusal dentin surfaces were then polished with 600-grit silicon carbide abrasive paper under running water for 30 s to obtain a uniform and standardized smear layer.

Bonding procedures
In both the primary and permanent teeth, the dentin surfaces were etched with 35% phosphoric acid gel (Scotchbond, 3M ESPE, St. Paul, USA) for 15 s, rinsed with water and gently blotted with absorbent paper to keep a moist surface. Two consecutive coats of the adhesive system (Adper Single Bond 2, 3M ESPE, St. Paul, USA) were applied, gently air dried, and light-cured for 10 s. Resin composite (Filtek Z250, 3M ESPE, St. Paul, USA) was built up on the bonded surfaces in increments of approximately 1.5 mm, and individually light-cured for 20 s (Led Olsen, Olsen Ind. e Com. S/A, Palhoça, Brazil), at 800 mW/cm². All specimens were stored in distilled water at 37°C for 24 h.

Microtensile bond strength (µTBS)
Specimens were serially sectioned longitudinally through the bond interface with a water-cooled diamond saw in a cutting machine (Labcut 1010, Extec Co., Enfield, USA) in order to obtain sticks with a cross-sectional area of approximately 0.8 mm², according to the microtensile “non-trimming” technique. The cross-sectional area of each stick was measured with a digital caliper (Absolute Digimat, Mitutoyo, Tokyo, Japan) for calculating bond strength. The sticks were carefully examined with a stereomicroscope at 30× magnification and those with defects at the resin-dentin interface were discarded.

The bonded sticks originating from the same teeth were randomly subdivided into 2 groups, according to storage time:
• immediately or
• for 6 months (in distilled water containing 0.4% sodium azide at 37°C).

The storage solution was not changed and its pH was monitored monthly. After each storage period, the bonded sticks were attached to a device for microtensile testing with cyanoacrylate resin and subjected to the microtensile test on a universal testing machine (DL 2000, Emic, São José dos Pinhais, Brazil) at a crosshead speed of 1 mm/min.

Failure mode
All debonded sticks were observed in a stereomicroscope (HMV II, Shimadzu, Kyoto, Japan) at 400× magnification to determine failure mode:
• adhesive/mixed (failure at the resin-dentin interface or mixed with cohesive failure of the neighboring substrate) or
• cohesive (failure exclusively within the dentin or resin composite).

Statistical analysis
The experimental unit in this study was the he-
mi-tooth, since half the sample was tested immedi-
ately and the other half was tested after 6 months.
Thus, means of the microtensile bond strength
(MPa) of all sticks from the same hemi-tooth was
averaged for statistical purposes. The microtensile
bond strength means for every testing group was
expressed as the average of the 5 teeth used per
group.

Normal distribution of data was confirmed using
the Kolmogorov-Smirnov test. Data obtained were
analyzed with two-way repeated measures ANOVA
using a factorial design with substrate (primary
or permanent dentin) and storage time (24 h or 6
months) as variables. Tukey’s HSD multiple com-
parisons statistical test at a 0.05 significance level
was used. Failure mode was only qualitatively evalu-
ated.

Results

Microtensile bond strength means (MPa) and
standard deviations for all experimental groups are
displayed in Table 1. The main factors dentin sub-
strate \( (p = 0.000) \) and storage time \( (p = 0.000) \),
as well as, cross-product interaction \( (p = 0.008) \) were
statistically significant.

The µTBS values significantly decreased after 6
months of water storage, regardless of dentin sub-
strate (around 20.5% to 32.1% for primary and
permanent teeth, respectively). In the immediate
evaluation, values obtained for primary dentin were
lower than those of permanent dentin. This differ-
ence was not maintained after aging.

Distribution of the failure mode is summarized
in Table 2. For all groups, adhesive/mixed failure
prevailed.

Discussion

There is no consensus in the literature concern-
ing the bonding of adhesive systems to primary and
permanent dentin.\(^6\) Based on the outcomes of
the current study it can be stated that the immedi-
ate bond strength of the etch-and-rinse adhesive is
higher in permanent dentin compared with primary
dentin, using the same bonding protocol. This find-
ing is in agreement with previous studies.\(^6,7,12,13\)

Differences in the percentage of mineral compo-
nents, tubular diameter and density and intrinsic
moisture of primary and permanent teeth may influ-
ence adhesive performance, resulting in lower µTBS
for primary dentin. While greater density of the tu-
bules and larger diameter\(^1\) result in a reduced area of
intertubular dentin available for bonding, the lower
mineral content\(^2\) reduce the buffering capacity and
increase the reactivity of primary dentin to acidic
solutions, resulting in the formation of thicker hy-
brid layers compared with permanent teeth.\(^3,4\)

Prolonged etching time tend to produce deeper
dentin demineralization,\(^5\) and subsequently, a non-
impregnated area along the bottom of the hybrid
layer that containing exposed collagen fibrils, more
prone to undergo enzymatic\(^14\) and hydrolytic\(^15-17\)
degradation over time. Even though several re-
searches have assessed the deterioration of resin-
dentin bonds in permanent teeth, information re-

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**Table 1 - Microtensile bond strength means (MPa) and standard deviations for all experimental groups.**

<table>
<thead>
<tr>
<th>Dentin substrate</th>
<th>Storage time</th>
<th>6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Immediate</td>
<td>30.7 ± 2.2(^b)</td>
</tr>
<tr>
<td>Permanente</td>
<td>Immediate</td>
<td>41.7 ± 2.7(^b)</td>
</tr>
</tbody>
</table>

Different letters indicate statistically significant difference \( (p < 0.05) \).

**Table 2 - Number and percentage of sticks (%) and total of sticks tested according to failure mode and premature failures for all experimental groups.**

<table>
<thead>
<tr>
<th>Storage time</th>
<th>Immediate</th>
<th>6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure mode</td>
<td>A/M</td>
<td>CD</td>
</tr>
<tr>
<td>Primary</td>
<td>29 (76.3%)</td>
<td>4 (10.5%)</td>
</tr>
<tr>
<td>Permanent</td>
<td>24 (70.6%)</td>
<td>9 (26.5%)</td>
</tr>
</tbody>
</table>

A/M: adhesive/mixed failure; CD: cohesive failure in dentin; CR: cohesive failure in resin; Premature failures: pre-testing failures due to specimens preparation or water storage time.
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Regarding their bonding stability to primary dentin is still limited.\textsuperscript{15,18-20}

In fact, degradation of resin-dentin bonds was observed in the current study, represented by a decrease in $\mu$TBS values after 6 months of water storage, as observed in previous studies.\textsuperscript{20,21} However, the reduction in bond strength was more pronounced for permanent dentin. Consequently, the difference observed in immediate $\mu$TBS values between permanent and primary dentin was not maintained after aging in water.

Although a greater degradation in resin-primary dentin bonds was expected, this result seems to confirm that a direct relationship does not appear to exist between bond strength and hybrid layer thickness,\textsuperscript{9,22} even though this variable was not evaluated in the current study. More relevant than hybrid layer thickness is its favorable and uniform interaction with the substrate.\textsuperscript{9} Another hypothesis for the minor reduction in $\mu$TBS values might be related to the lower values obtained immediately and not to a lower susceptibility to degradation.

Thus, shortening the acid etching time of dentin has been considered in order to improve the immediate bond strength and, subsequently, the longevity of adhesive interfaces produced in primary teeth.\textsuperscript{22,23} Likewise, the use of metalloproteinase inhibitors, as chlorhexidine digluconate, does not negatively influence the immediate bond strength and prevents, or least decelerates the deterioration of resin-dentin bonds in primary\textsuperscript{19,20} and permanent teeth.\textsuperscript{24,25}

Since only one property of the adhesive systems was evaluated in the current study, further researches evaluating other bonding properties and different adhesive bonding approaches should be conducted to elucidate the durability of resin-dentin interfaces in primary teeth.

Conclusion
Degradation of resin-dentin bonds of the etch-and-rinse adhesive system occurred after 6 months of water storage; however, the reduction in bond strength values was higher for permanent teeth.

References


