A comparison of two dentin bonding agents in primary and permanent teeth

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Abstract

The shear bond strengths of 2 dentin bonding techniques were tested on primary and permanent teeth. No significant differences were noted between the mean bond strengths for primary and permanent teeth or between the Scotchbond® Dental Adhesive System and a method utilizing ferric oxalate, NTG-GMA, and PMDM. Microscopic examination revealed that the majority of bond failures occurred at the dentin-resin interface.

Methods and Materials

Twenty noncarious human primary molars and 20 noncarious human maxillary third molars were embedded in copper tubes which had been filled with improved dental stone. The teeth were placed in the stone so that the clinical crowns remained exposed. An engraver pantograph was used to expose flat surfaces of dentin on the buccal, lingual, distal, and mesial surfaces of the teeth (Fig 1). Three of the 4 surfaces of each tooth were selected for resin application by a random allocation method.

Three techniques were investigated as dentinal adhesives including: (1) a control consisting of an unfilled composite resin applied to untreated dentin; (2) Bowen’s method using ferric oxalate, NTG-GMA, and PMDM; and (3) the Scotchbond dental adhesive.

The ferric oxalate, NTG-GMA, and PMDM solutions used in the Bowen technique were prepared as suggested by Bowen et al. The solutions were stored in amber-colored glass bottles until used.

The control resin was applied to dentin which had been cleaned using a pumice-water slurry. The ferric oxalate, NTG-GMA, and PMDM solutions used in the Bowen technique were applied to the dentin surfaces following the technique suggested by Bowen et al. (Table 1). The Scotchbond adhesive was applied to dentin surfaces which had been cleaned using a pumice-water slurry according to the manufacturer’s directions.

Following applications of each dentinal bonding material (and after cleaning in the case of the control resin) a large elastic separator was placed on the dentin surface and filled with a light-cured composite resin (universal shade) to form a resin “button.” The resin button was polymerized for 20 sec using a standard light source.

Bond strengths of the materials were determined in the shear mode using a testing machine. A 500-kg load cell was used in the testing machine with a 10-kg full scale range and a crosshead speed of 0.15 cm/min. Microscopic examination was used to evaluate several of the specimens before and after shear testing.

Upon completion of the initial data collection, new information became available concerning the preparation of the chemicals used in the Bowen technique. New solutions of ferric oxalate, NTG-GMA, and PMDM were prepared based on the new recommendations of Bowen and Cobb as follows: (1) ferric ox-

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a GAC International: Commack, NY.

b Silux Enamel Bond resin — 3M Dental Products: St Paul, MN.

c Scotchbond Dental Adhesive System — 3M Dental Products: St Paul, MN.

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References

144  DENTIN BONDING AGENTS/COMPARISON: Fagan et al.
FIG 1. Engraver pantograph exposing flat surfaces of dentin on the buccal, lingual, distal, and mesial surfaces on a tooth embedded in stone in a copper tube.

TABLE 1. Technique for Application of Ferric Oxalate, NTG-GMA, and PMDM

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Apply a drop of ferric oxalate solution for 60 sec.</td>
</tr>
<tr>
<td>2.</td>
<td>Distilled water rinse for 10 sec.</td>
</tr>
<tr>
<td>3.</td>
<td>Blow surface with air for 10 sec.</td>
</tr>
<tr>
<td>4.</td>
<td>Apply 1 drop NTG-GMA for 10 sec.</td>
</tr>
<tr>
<td>5.</td>
<td>Remove excess solution with a cotton swab.</td>
</tr>
<tr>
<td>6.</td>
<td>Apply 1 drop acetone for 10 sec.</td>
</tr>
<tr>
<td>7.</td>
<td>Remove excess solution with a cotton swab.</td>
</tr>
<tr>
<td>8.</td>
<td>Blow surface with air for 10 sec.</td>
</tr>
<tr>
<td>9.</td>
<td>Apply a drop of PMDM solution for 60 sec.</td>
</tr>
<tr>
<td>10.</td>
<td>Blow surface with air for 10 sec.</td>
</tr>
<tr>
<td>11.</td>
<td>Place composite material and polymerize.</td>
</tr>
</tbody>
</table>

Ferric oxalate was prepared under safelight conditions; (2) the NTG-GMA acetone solution was stored anaerobically; and (3) the NTG-GMA solution was used the day following its preparation. Unused proximal surfaces on the 10 permanent molars that had been used in the first experiment were reprepared on the engraver pantograph so as to expose fresh dentin surfaces. The new solutions of ferric oxalate, NTG-GMA, and PMDM were applied to the dentin surfaces and a resin button was placed following the same technique used in the first study. These specimens then were subjected to shear testing as previously described.

Results

The specimens were examined at the composite resin-dentin interface with a dissecting microscope. Four of the Bowen-bonded specimens had resin remaining on the dentin surface indicating a fracture within the resin. The measured shear values for these 4 specimens were 28.9, 49.5, 53.9, and 107.8 kg/cm². The other 53 specimens had no resin remaining and therefore the shear strengths for these specimens measured adhesive strengths between resin and dentin.

All of the control specimens became dislodged before they could be shear tested. Bond values were assigned a value of 0 for these 20 specimens. The control groups on both primary and permanent dentin were determined to be significantly different from the other treatment groups by an analysis of variance (ANOVA) (F = 10.53, p < 0.001) and Duncan's multiple range test (Table 2). The control group was removed from further statistical analysis because of a lack of variation.

The modified Bowen technique (ferric oxalate mixed under safelight conditions and NTG-GMA stored anaerobically) gave the highest average shear bond strength for primary and permanent teeth combined (x = 73.0 kg/cm², SD = 37.2); the original Bowen mixture was intermediate (x = 51.9 kg/cm², SD = 30.8); and Scotchbond had the lowest mean bond strength (x = 44.4 kg/cm², SD = 29.0). Differences among the 3 dentin bonding groups were not statistically significant (F = 2.63, p = 0.08).

ANOVA was used to determine whether a significant difference existed between the means for Bowen's technique in primary and permanent teeth and Scotchbond in primary and permanent teeth. There were no significant differences between these groups (F = 0.46, p = 0.71).

ANOVA was performed to see whether there was a significant difference in dentin bonding between primary and permanent dentin (Bowen technique in primary vs. permanent teeth: F = 0.4, p = 0.54; Scotchbond adhesive in primary vs. permanent teeth: F = 0.43, p = 0.52). No significant differences between dentin bond strengths in primary and permanent teeth were noted.

Discussion

The mean shear bond strength value for the modified Bowen technique was 30 kg/cm² greater than the

<table>
<thead>
<tr>
<th>Material/Tooth Type*</th>
<th>N</th>
<th>Mean (kg/cm²)</th>
<th>Standard Deviation (kg/cm²)</th>
<th>DMR**</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>10</td>
<td>56.3</td>
<td>34.2</td>
<td>(A)</td>
</tr>
<tr>
<td>B2</td>
<td>10</td>
<td>47.5</td>
<td>28.2</td>
<td>(A)</td>
</tr>
<tr>
<td>S1</td>
<td>7</td>
<td>38.8</td>
<td>25.3</td>
<td>(A)</td>
</tr>
<tr>
<td>S2</td>
<td>10</td>
<td>48.4</td>
<td>32.1</td>
<td>(A)</td>
</tr>
<tr>
<td>C1</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>(B)</td>
</tr>
<tr>
<td>C2</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>(B)</td>
</tr>
</tbody>
</table>

* B1 — Bowen technique on primary teeth; B2 — Bowen technique on permanent teeth; S1 — Scotchbond on primary teeth; S2 — Scotchbond on permanent teeth. C1 — Control on primary teeth; C2 — Control on permanent teeth.

** Means which are significantly different at p < 0.05 are designated by different letters.
mean bond strength for the Scotchbond adhesive in this study. Nevertheless, this difference was not statistically significant. The clinical significance of these findings presently is unknown.

Large variations in shear strength values were noted in this study. Joos has stated that variability of scores is quite common in dental adhesion studies and that such variations are due to differences among test teeth.\(^1\)

Laboratory tests for composite resins bonded to acid-etched enamel have produced shear bond strengths of approximately 211 kg/cm\(^2\).\(^6\) The present study found mean shear bond strength values for dentin bonding of 44 and 73 kg/cm\(^2\) for the Scotchbond adhesive and Bowen’s technique, respectively. Thus, these 2 dentin bonding products exhibited bond strengths which were only 20-35% of the bond strengths reported for composite resins bonded to acid-etched enamel. Nevertheless, this additional bonding may be clinically significant in some situations. The increased retention of composite materials through the use of dentin bonding agents might make possible more conservative cavity preparations and ultimately lead to preservation of tooth structure, a fundamental concept of operative dentistry. The amount of marginal microleakage also might be significantly decreased, thereby reducing the recurrence of decay.

The mean shear values obtained in this study for the Scotchbond adhesive were similar to mean values reported by other investigators. No reports of shear bond values for the Bowen technique were found in the literature. Previous investigations have tested the Bowen method for tensile strength and have reported average values of 134 kg/cm\(^2\).\(^3\)\(^\text{4}\)\(^\text{6}\) The present evaluation found mean shear strength values of 73 kg/cm\(^2\).

One might have expected to observe greater shear strength for the Bowen technique than was found in this study because of the higher tensile strength reported by other investigators. This study attempted strict adherence to the protocols established for the preparation and use of the chemicals in the Bowen technique. However, the preparation and sequential applications of ferric oxalate, NTG-GMA, and PMDM is a complex and exacting procedure involving many interacting variables which may alter or affect the degree of bonding. The differences found in this study between mean shear strengths of the original Bowen mixture and the modified Bowen mixture illustrate the sensitivity of this technique to the many variables involved in the Bowen method. One would expect that simplification of this technique would yield more consistent results.

The current Bowen method does not lend itself to practical clinical use. The mixing of the chemicals used in the technique is a tedious procedure. Because the NTG-GMA solution becomes unstable after several weeks, freshly prepared solutions are recommended. The practitioner would have to mix this solution in his office because of the short shelf life of the mixture and store it under anaerobic conditions. The actual application of the ferric oxalate, NTG-GMA, and PMDM solutions onto tooth structure is time consuming, the entire procedure taking at least 4 min to accomplish. Application of the Scotchbond adhesive is much easier and less time consuming.

**Conclusions**

Based on the findings of this study, the following conclusions were made.

1. There was no statistically significant difference between the shear strengths of the Bowen technique and the Scotchbond adhesive.
2. There was no statistically significant difference between dentin bond strengths in primary teeth and permanent teeth using these techniques.
3. Shear bond failure occurred at the resin-dentin interface in the majority of specimens with these techniques.
4. The Scotchbond adhesive would seem to be more practical for clinical use than the Bowen technique at this time because the adhesive requires no preparation and is applied more easily.

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