PEDIATRIC DENTISTRY/Copyright ©1986 by
The American Academy of Pediatric Dentistry
Volume 8 Number 2

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

Timothy R. Fagan, DDS, MS James J. Crall, DDS, MS Mark E. Jensen, DDS, PhD
Yvonne Chalkley, DDS, MS Brian Clarkson, BChD, LDS, MS, PhD

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[a] 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[b] applied to untreated dentin; (2) Bowen's method using ferric oxalate, NTG-GMA, and PMDM;[1,2] and (3) the Scotchbond[c] dental adhesive.

The ferric oxalate, NTG-GMA, and PMDM solutions used in the Bowen technique were prepared as suggested by Bowen et al.[3] 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.[3,4] (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[d] was placed on the dentin surface and filled with a light-cured composite resin[b] (universal shade) to form a resin "button." The resin button was polymerized for 20 sec using a standard light source.[e]

Bond strengths of the materials were determined in the shear mode using a testing machine.[f] 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 preparation of the dentin surfaces and following 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[5] as follows: (1) ferric ox-

[a] Model P1-3 — Gorton Machine Corp: Racine, WI.
[b] Silux Enamel Bond resin — 3M Dental Products: St Paul, MN.
[c] Scotchbond Dental Adhesive System — 3M Dental Products: St Paul, MN.
[d] GAC International: Commack, NY.
[e] Prisma Lite, Model PR-1 — LD Caulk Co: Milford, DE.
[f] Instron Universal Testing Machine — Instron Corp: Canton, MA.

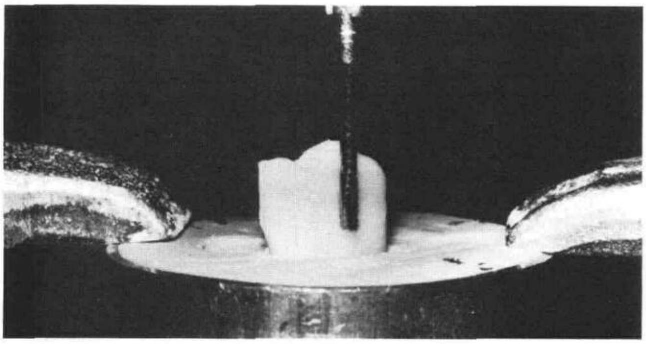

Fig 1. Engraver pantograph exposing flat surfaces of dentin on the buccal, lingual, distal, and mesial surfaces on a tooth embedded in stone in a copper tube.

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

1.	Apply a drop of ferric oxalate solution for 60 sec.
2.	Distilled water rinse for 10 sec.
3.	Blow surface with air for 10 sec.
4.	Apply 1 drop NTG-GMA for 10 sec.
5.	Remove excess solution with a cotton swab.
6.	Apply 1 drop acetone for 10 sec.
7.	Remove excess solution with a cotton swab.
8.	Blow surface with air for 10 sec.
9.	Apply a drop of PMDM solution for 60 sec.
10.	Blow surface with air for 10 sec.
11.	Place composite material and polymerize.

alate 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/cm^2. 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/cm^2, $SD = 37.2$); the original Bowen mixture was intermediate ($x = 51.9$ kg/cm^2, $SD = 30.8$); and Scotchbond had the lowest mean bond strength ($x = 44.4$ kg/cm^2, $SD = 29.0$). 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/cm^2 greater than the

Table 2. Mean Shear Strengths, Standard Deviations, and Duncan's Multiple Range Test Results (DMR) for Control, Original Bowen and Scotchbond Techniques on Primary and Permanent Dentin

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

* 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.[3,4,6] 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.

This study was supported by USPHS Grant 5S07-RR5313.

Dr. Fagan is in private pediatric dentistry practice in Enid, Oklahoma; Dr. Crall is an associate professor, pediatric dentistry; Dr. Jensen is an assistant professor and Dr. Clarkson is a professor, Dows Institute for Dental Research; and Dr. Chalkley is an associate professor, operative dentistry, University of Iowa. Reprint requests should be sent to: Dr. Timothy R. Fagan, 1002 W. Maple, Suite B, Enid, OK 73701.

1. Joos RW: Status of adhesives of dentin. Northwest Dent 59:224–27, 1980.
2. Causton BE, Johnson NW: The influence of mineralizing solutions on the bonding of composite restorations to dentin. Cyanacrylate pretreatment. J Dent Res 60:1315–20, 1980.
3. Bowen RL, Cobb EN, Rapson JE: Adhesive bonding of various materials to hard tooth tissues: improvement in bond strength to dentin. J Dent Res 61:1070–76, 1982.
4. Bowen RL, Cobb EN, Setz LE: Adhesive bonding to dentin and enamel. Dentistry 2:11–13, 1982.
5. Bowen RL, Cobb EN: Provisional guide for the use of experimental materials that improve bonding of composites to dentin and enamel. Third draft. (unpublished data)
6. Council on Dental Materials, Instruments, and Equipment: Resin dentin bonding system. J Am Dent Assoc 108:240–41, 1984.