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Influence of Zinc-Oxide Eugenol, Formocresol, and Ferric Sulfate on Bond Stength of Dentin Adhesives to Primary Teeth

Fouad Saad Salama, BDS, MS

Abstract

This study evaluated *in vitro* the influence of a temporary filling {zinc oxide-eugenol (ZOE)} and two pulpotomy agents {formocresol (FC) and ferric sulfate (FS)} on shear bond strength (SBS) of two dentin adhesives to the dentin of primary molars. A total of 80 dentin surfaces were prepared and randomly allocated into 10 groups of 8 specimens each. Groups were subjected to different treatments, which included covering with a paste of ZOE mixed at different powder:liquid (P:L) ratios, placement on a gauze soaked in FC or FS, or they received no pretreatment and served as a control. XRV™ Herculite® composite cylinders were bonded to dentin surfaces using Prime and Bond® NT adhesive resin or Opti Bond Solo Plus adhesive resin. SBSs were determined using the Instron® testing machine running at a crosshead speed of 0.5 mm/min. The use of ZOE mixed at the lower P:L ratio of 10g:2g significantly decreased the values of SBS of the two adhesives. The use of two pulpotomy agents (FC and FS) significantly decreased the SBS of the two adhesives. The bond strength to dentin of primary teeth was influenced by the pulpotomy agents used and the ZOE P:L ratio but not by the adhesive system used.

Keywords: Dentin bonding, primary teeth, zinc oxide-eugenol, formocresol, ferric sulfate

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Introduction

Several studies have evaluated shear bond strength (SBS) of composite resin using different adhesive systems to primary and permanent dentin and demonstrated higher or lower bond strength to primary teeth compared to permanent teeth.[1, 2] Furthermore, dentin contamination by water, saliva, blood, eugenol-containing temporary filling materials, or pulpotomy agents, such as formocresol (FC), could have a detrimental effect on bond durability of composite resin and dentin bonding systems.[3-5]

Zinc oxide-eugenol (ZOE) is one of the most commonly used temporary filling materials in endodontics and restorative dentistry. Restorative materials containing ZOE have not been recommended as temporary fillings or cementing materials, liners, or bases under resin composite restorations due to their adverse effects on bond strength of resin-based restorative materials.[3, 6, 7] The lowered degree of conversion of resin composites cured in contact with ZOE cements has been found to lead to increased surface roughness, reduced microhardness, and reduced color stability.[6, 8] Pulpotomy agents, such as FC, could also have a detrimental effect on bond durability of composite resin and dentin bonding systems. FC delivered by paper points to the root canals of human teeth crystallize both on dentin walls and inside dentinal tubules9 and may influence the bond strength values in permanent teeth.[4, 10, 11]

It is crucial to study and determine the effect of surface contamination with the different materials used in dentistry for children on the bond strength of dentin bonding agents to primary teeth. Therefore, the purpose of this *in vitro* study was to evaluate the influence of a temporary filling (ZOE) and two pulpotomy agents {(FC and ferric sulfate (FS)} on SBS of two dentin adhesives to the dentin of primary molars.

Materials and Methods

Forty non-carious human primary molars were extracted and stored at room temperature in an aqueous solution of 0.1% thymol for no longer than 3 weeks before they were used. The crowns were sectioned from the roots at the cementobuccal enamel junction and each crown was cut longitudinally in a mesiodistal direction. The facial and lingual surfaces of the crowns were embedded in autopolymerizing resin with the facial or lingual surfaces exposed. Dentin surfaces were ground (wet) into a flat surface using a standardized technique with a series of 180 _ , 320 _ , and 600 _ silicon carbide abrasive paper using a grinder/polisher (Automata, Jeanuuirtz Co, West Germany). A total of 80 dentin surfaces were prepared and randomly allocated into 10 groups of 8 specimens each (Table 1). Specimens in groups 1 and 6 received no pretreatment and served as a control. Specimens in groups 2 and 7 were covered with a paste of ZOE (Chemtest Laboratories Inc., USA) mixed at powder:liquid (P:L) ratio of l0g:lg. Specimens in groups 3 and 8 were treated in a similar manner to groups 2 and 7 but ZOE was mixed at a lower P:L ratio of 10g:2g. Specimens in groups 2, 3, 7, and 8 were covered with tinfoil and stored in closed containers filled with distilled water at 37°C for 7 days. After that time, the ZOE was mechanically removed with an ultrasonic scaler until the dentin surfaces were macroscopically free of the material. Specimens in groups 4 and 9 were placed on gauze soaked in FC (PD Produits Dentaires, Switzerland), sealed in closed containers, and kept at 37°C for 2 days. The groups were pre-treated for different periods following the method described by Soeno et al.4 Specimens in groups 5 and 10 were placed on gauze soaked in FS (Astringedent®, Ultradent, USA), sealed in closed containers, and kept at 37°C for 2 days. All specimens were rinsed with tap water for 15 seconds and dried with oil-free compressed air for 5 seconds before bonding.

An adhesive masking tape with a circular hole (3 mm in diameter) was applied to the prepared dentinal surface so the dentin adhesive was

applied to a standardized area. The application of the two adhesive systems was carried out according to the instructions given by the manufacturers. Prime and Bond® NT adhesive resin (Dentsply/Caulk, USA) was applied for groups 1–5 and Opti Bond Solo Plus adhesive resin (sds Kerr, Sybron Dental Specialties, USA) was applied for groups 6–10 (Table 1). A resin composite, XRV™ Herculite® (sds Kerr, Sybron Dental Specialties, USA) was handled according to the instructions of the manufacturer and placed in two increments onto the dentin surfaces via clear plastic tubes that were 3 mm high with an internal diameter (ID) of 3 mm, which were placed perpendicular to dentin surfaces. All specimens were stored in closed containers filled with distilled water at 37°C for 24 hours. SBSs were determined using an Instron (Instron Limited, England) testing machine running at a crosshead speed of 0.5 mm/min. The SBSs were calculated and expressed in MPa. Statistical analysis was conducted using non-parametric one-way analysis of variance (Kruskal-Wallis test) with a Tukey Post Hoc test. The level of significance was chosen at P=0.05.

Results

The mean, standard deviation, and range of the SBS measurements in ascending order expressed in MPa are presented in Table 2. There was no significant difference between the SBS to dentin for the two adhesive systems in the control groups 1 and 6 (P>0.05).

One way analysis of variance indicated significant differences in bond strengths between the ten surface treatments (P<0.0001) {Table 2}. Tukey's multiple range test showed SBS of Prime and Bond® NT in group 2 (ZOE – P:L, 10g:1g) was statistically significantly higher than group 3 (ZOE - P:L, 10g:2g) (P<0.0001). SBS of Opti Bond Solo Plus in group 7 (ZOE - P:L, 10g:1g) was also statistically significantly higher than group 8 (ZOE - P:L, 10g:2g) (P<0.0001). Increasing the P:L ratio of ZOE in groups 3 and 8 decreased the values of SBS of the two adhesive systems

Table 1. Materials and surface treatment used in the present study.

Group Number	Adhesive	Surface Treatment
1	Prime and Bond® NT	No treatment – Control
2	Prime and Bond® NT	ZOE - (P:L) l0g:lg -7 days
3	Prime and Bond® NT	ZOE - (P:L) l0g:2g -7 days
4	Prime and Bond® NT	FC - 2 days
5	Prime and Bond® NT	FS - 2 days
6	Opti Bond Solo Plus	No treatment - Control
7	Opti Bond Solo Plus	ZOE - (P:L) l0g:lg -7 days
8	Opti Bond Solo Plus	ZOE - (P:L) l0g:2g 7 days
9	Opti Bond Solo Plus	FC - 2 days
10	Opti Bond Solo Plus	FS - 2 days

Table 2. Shear bond strength in MPa for all groups.

Group No.	Mean*	Standard Deviation (SD)	Range	N
9	7.30 [a]	0.84	6.30 – 8.40	8
8	7.58 [a]	0.57	6.70 – 8.30	8
4	8.26 [ab]	0.76	7.40 – 9.30	8
3	8.53 [ab]	0.60	7.60 – 9.20	8
10	9.51 [bc]	0.96	8.10 – 10.80	8
5	10.45 [cd]	0.90	9.10 – 11.70	8
7	11.34 [de]	0.70	10.40 – 12.60	8
6	11.7 [def]	0.92	10.10 – 13.20	8
2	12.33 [ef]	0.62	11.50 – 13.30	8
1	12.74 [f]	0.88	11.20 – 14.10	8

* No statistically significant difference between the values with the same superscript letters

to the dentin of primary molars. There was a statistically significant difference between Prime and Bond® NT in groups 3 (ZOE - P:L, 10g:2g) and 4 (FC 2 days) and that of groups 1, 2, 5, 6, and 7 ($P<0.0001$). The use of FS demonstrated a significant difference between Opti Bond Solo Plus in group 10 and that of groups 1, 2, and 6 ($P<0.0001$).

The bond strength to dentin of primary teeth was influenced by the two pulpotomy agents used (FS and FC) as well as with the use of a higher P:L ratio of the temporary filling (ZOE) but not by the adhesive system used.

Discussion

Consistent dentin bonding is essential to the clinical success of restorative dentistry, and it is important to examine whether ZOE temporary filling material and pulpotomy agents, such as FC and FS, would reduce the efficacy of the dentin-bonding systems to dentin of primary teeth. Therefore, the purpose of this in vitro investigation was to examine whether ZOE, FC, and FS would influence the SBS of two modern dentin bonding systems to the dentin of primary molars. The mean SBS values for the control groups in the present study were consistent with values found in the literature.[1, 2] The mean SBS for the group 1 (Prime and Bond® NT – no surface treatment/control) specimens was the highest among all groups, while group 9 (Opti Bond Solo Plus – FC – 2 days) showed the lowest SBS. The results of the present study demonstrate that use of ZOE mixed at the lower P:L ratio of 10g:2g decreased the values of SBS of the two dentin adhesives used. Also, the use of two pulpotomy agents (FC and FS) significantly decreased the SBS of the two adhesives. A suitable explanation for these results is the use of ZOE mixed at the lower P:L ratio of 10g:2g for 7 days and FC or FS for 2 days produced surface changes of dentin, which affected bonding of the two dentin adhesives and caused lower values of SBS. In addition ZOE's adverse effects on resin-based restorative materials have been attributed to either change in the wetability and reactivity of the dentin[12, 13] or to remnants of the material on the surface that may interact with the setting of resin composites.[8, 13] ZOE may penetrate the underlying dentin surface and, thus, interfere with

the polymerization reaction.[14] Some investigators agree, while others disagree, with this concept regarding the effect of ZOE-containing materials on resin-based restoratives when some dentin adhesives are employed.[3, 6, 7, 11, 15] The observed effect of the ZOE materials on the bond strength may be related to the softening effect on dentin due to demineralization, which may theoretically influence the bond strength.[15] In addition mechanical removal of ZOE may not be 100% effective, as it has been reported temporary cement remnants were observed microscopically on surfaces that appeared macroscopically clean.[13] In the present study the use of FC for 2 days decreased SBS of Prime and Bond® NT and Opti Bond Solo Plus to primary teeth. Other studies using FC showed decrease or increase of bond strength.[4, 16] High bond strength reported with the use of FC has been attributed to the cross-bonding structures formed by formaldehyde, which can fixate the proteins and stabilize the collagens in dentin.[4, 17] Pretreatment of class V cavities of extracted, non-carious human premolars with ZOE mixed at a P:L ratio of 10g:2g significantly increased microleakage and was not recommended clinically.[18]

Conclusion

Under the conditions of this in vitro study we concluded:

1. SBS was influenced by the pulpotomy agents (FC and FS) used and the ZOE P:L ratio but not by the adhesive system used in the present study.
2. The use of ZOE did not affect SBS of Prime and Bond® NT and Opti Bond Solo Plus when powder/liquid ratio of l0g:lg was used.
3. The use of ZOE mixed at lower powder/liquid ratio of 10g:2g and FC or FS for 2 days significantly decreased the values of SBS of Prime and Bond® NT and Opti Bond Solo Plus to primary teeth dentin.

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About the Author

Fouad Saad Salama, BDS, MS

Dr. Salama is an Associate Professor and the Director of the Pediatric Dentistry Residency Program, Department of Growth and Development, University of Nebraska Medical Center, College of Dentistry in Omaha, NE.

e-mail: fsalama@unmc.edu